

# **CASWELL GAME LAND AQUATIC INVENTORY**


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# CASWELL GAME LAND AQUATIC INVENTORY

## Introduction

Caswell Game Land is located in Caswell County, North Carolina, approximately 2 km southeast of Yanceyville. The 16,614-acre game land lies within the Roanoke River Basin, which originates in south-central Virginia and extends from north-central North Carolina to the Albemarle Sound. This watershed encompasses part of 15 counties and has an area of nearly 3,500 square miles with more than 2,400 stream miles. The primary sources of water in this river basin come from surface waters that support the 12 man-made lakes in North Carolina and Virginia. The major waterways associated with Caswell Game Land include Farmer Lake, Hyco Lake, Country Line Creek, Hyco Creek, and their associated tributaries.

The North Carolina Wildlife Resources Commission (NCWRC) purchased Caswell Game Land on 3 November 1958 from the U.S. Forest Service. The game land is divided into 11 blocks, with forests covering approximately 90% of the area and the remaining 10% made up of fields, trails, roads, streams, and lakes. During the early part of the 1900s, the game land was a mosaic of small farms. However, after years of poor land management practices, the productivity of many of these farms was severely depleted. Presented with poor growing conditions and the economic plight of the 1930s, many tracts of land were sold to the federal government. Eventually, the U.S. Forest Service became the owner and administered these tracts as national forests until late 1958. After the NCWRC purchased these properties, a long-range management plan was prepared with the stated objective of "conducting a program of coordinated timber and wildlife management for the benefit of the sportsmen of the State of North Carolina." Overall, hunting on the game land is the primary public use, ranging from moderate to heavy for endemic wildlife such as turkey, deer, and quail, to low for rabbit and woodcock. An effort to establish a high-sustained yield of all major game species is the primary goal on Caswell Game Land and this objective is administered in a number of ways. Fields are managed in a system of coordinated cropping of materials for small game habitat improvement, and patch plantings of materials improve local quail, turkey, dove, and deer populations. Farming operations incorporate soil and water conservation practices, and ample food and cover are left for wildlife during the harvesting of crops. Attempts to improve forest habitat through the seeding of forest openings and trails, and prescribed burning and thinning have been implemented. Fishing opportunities within the game land also are available with the accessibility of numerous streams and 2 impoundments, 5 and 8 acres in size.

Land use in the areas surrounding Caswell Game Land primarily consists of agriculture. A visual survey of the area reveals numerous corn and tobacco fields, and a fair number of cow pastures. Horses and goats also are noticed at scattered locations across the landscape. Logging does not seem to be prevalent within the area, as much of the landscape is forested. However, a few tree farms and logging operations are present. Overall, the landscape in Caswell County is relatively undeveloped with Yanceyville serving as the largest city within the county.

The objective of this project was to survey Caswell Game Land for aquatic species, including mussels, sphaeriid clams, snails, crayfish, and fish. Our goals were to determine species



presence, distribution, relative abundance, and relative health. The inventory included waterways within and around Caswell Game Land within Caswell County, North Carolina. Figure 1 details the localities of all the sites surveyed. The following sections provide results of the aquatic inventory for each of the taxa mentioned above. For purposes of this report, *Corbicula fluminea* (Asian clam) was grouped with the sphaeriid clams even though the 2 taxa belong to different families.

## Acknowledgements

We would like to thank the following people, without whose assistance this project would not have been possible: John M. Alderman (NCWRC) for reviewing and editing the report and getting us started with the survey; Steve Harris and Chris Henline of the Caswell Game Land Depot (NCWRC) for providing us with maps of the game land and showing us the back roads through the game land; Dr. John E. Cooper, Dr. Arthur E. Bogan, Dr. Wayne C. Starnes, and Gabriela B. Mottes from the NC State Museum of Natural Sciences for providing assistance with identifications of crayfish, mollusks, and fishes, respectively; Dr. Gerald L. Mackie from the University of Guelph, Ontario, Canada, for providing assistance with sphaeriid identifications. We also would like to thank the landowners and residents of Caswell County, North Carolina, who allowed us to work on their property and showed an interest in their local natural history. A special thanks goes to Gordon Bendall of the Caswell Messenger for publishing an article that provided the citizens of Caswell County the opportunity to learn what the project entailed and the importance of nongame species.

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                              Aimee H. Fullerton, Nongame Technician III  
                              Nongame and Endangered Wildlife Program

## Sites surveyed

1. 980610.5, 980618.1, 980721.2
2. 980610.7, 980623.1, 980721.4
3. 980624.1, 980708.3, 980721.10
4. 980624.2 and 980721.11
5. 980624.3 and 980722.4
6. 980624.4 and 980722.3
7. 980625.1
8. 980625.2 and 980722.2
9. 980609.2, 980625.3, 980722.5
10. 980610.6, 980629.1, 980721.3
11. 980629.2 and 980721.9
12. 980629.3 and 980721.7
13. 980701.1
14. 980701.2 and 980721.6
15. 980701.3
16. 980702.1 and 980721.5
17. 980702.2
18. 980702.3
19. 980707.1 and 980722.7
20. 980707.2 and 980722.8
21. 980707.3 and 980722.6
22. 980708.1
23. 980708.2
24. 980709.1 and 980722.1
25. 980709.2 and 980721.12
26. 980709.3
27. 980714.1 and 980720.5
28. 980714.2 and 980721.1
29. 980714.3 and 980720.4
30. 980715.1 and 980720.1
31. 980715.2 and 980720.2
32. 980715.3 and 980720.3
33. 980715.4
34. 980716.1
35. 980716.2 and 980721.8

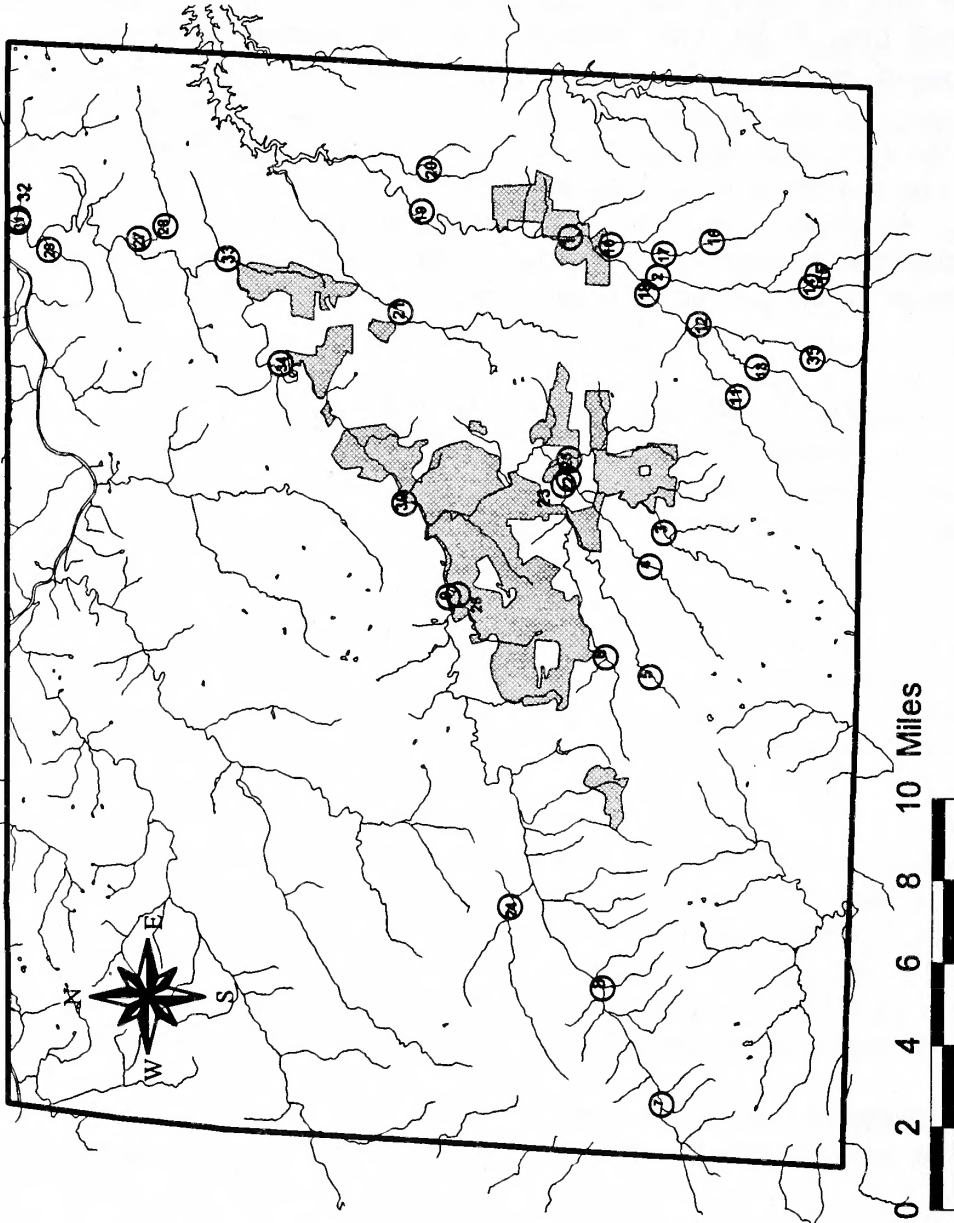


Figure 1. Map of sites surveyed during the aquatic inventory of Caswell Game Land, Caswell County, North Carolina, 1998. Each numbered location corresponds to one or more of the sites surveyed (upper right). The location of the game land within Caswell County, and the location of Caswell County within the state of North Carolina, are shown to the lower right.





# FRESHWATER MUSSELS AND SPHAERIID CLAMS

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NC Wildlife Resources Commission

## Introduction

The freshwater mussel fauna (Bivalvia: Unionoidea), also referred to as unionids or pearly mussels, is an intriguing, diverse, and important group of mollusks. Unionids are often prominent in macrobenthic aquatic communities where, for the most part, they are sedentary filter-feeders. Because unionids consume a major portion of the suspended particulate matter, they provide a number of important roles in aquatic ecosystems, two of which include serving as biological filters and water quality indicators. Mussels also serve as an important dietary component to a number of animals, and economically, their shells provide the nuclei used in the profitable cultured pearl industry (Theil and Fritz 1993). While not as much information has been ascertained for the sphaeriid clams (Bivalvia: Sphaeriidae), also called pea, pill, nut, or fingernail clams, they too serve an important role in aquatic ecosystems as filter-feeders. As part of the inventory of aquatic animals associated with the state-owned Caswell Game Land, we conducted field surveys of freshwater mussels and sphaeriid clams found in waterways occurring in and around the game land to better understand the taxonomy, distribution, and conservation needs of the taxa in North Carolina.

## Life History

The life cycle of freshwater mussels is an intricate process that is fairly unique when compared to that of other organisms. Spawning begins with the release of sperm from the excurrent aperture of mature males. As the sperm passively drift with the currents, they enter females through their incurrent aperture. Within sexually mature females, fertilization takes place in the suprabranchial cavity and the resulting embryos are retained in the marsupial gills until they develop into parasitic larvae called glochidia. Glochidia are obligate parasites and must attach to suitable host fishes. Ortmann (1911) described 2 general reproductive modes for unionids based on the length of time that glochidia were retained in the gills of the female. Bradytictic, or long-term brooders, typically spawn in late summer, brood young over the winter, and release mature glochidia during the following spring or early summer. Tachytictic, or short-term brooders, typically spawn in the spring and release mature glochidia sometime during that summer.

Once maturity is reached, the glochidia are released into the water column through the female's excurrent aperture, from specialized gill pores, or by rupture of the ventral portion of the gill (McMahon 1991). Once released by the female, glochidia passively drift with the currents until they attach to suitable host fishes or die. Mechanisms promoting glochidia-fish contact include respiratory, feeding, and spawning activities of fishes, as well as specialized morphologies and behaviors of particular mussel species (Kraemer 1970, Dartnall and Walkey 1979, Zale and Neves 1982). Attachment occurs on the gills, fins, or scales, depending on the mussel subfamily, and is followed by encystment and metamorphosis into juveniles. Metamorphosis generally occurs over a period of 1-3 weeks (Neves 1991), but can last for a few months (Zale and Neves



1982). Once metamorphosis is complete, the juvenile mussel drops from the host fish and settles into the surrounding substratum where, if conditions are suitable, growth until sexual maturity will occur and the reproductive cycle is repeated.

Unlike unionids, sphaeriid clams are ovoviviparous, self-fertilizing hermaphrodites. All species brood developing embryos in specialized chambers where maternal nutrients are supplied to the embryos. After maturity is reached, the once developing embryos are released into the water column as miniature adults. Due to their relatively large size as mature embryos when compared to other freshwater bivalves (Mackie 1984), most juvenile sphaeriids disperse between drainage systems by clamping their shells onto things such as aquatic insects (McMahon 1991), feathers of waterfowl (Burky 1983), or the limbs of salamanders (Davis and Gihen 1982), rather than dispersal by water currents. Given the high amount of variability seen between populations, sphaeriids typically have 1-3 reproductive efforts per year (McMahon 1991). *Corbicula fluminea* reproduces in much the same manner as sphaeriid clams, but tends to use the water currents as its primary means of dispersal (Williams and McMahon 1986). Most populations of the Asian clam have 2 reproductive efforts per year, one in the spring and the second in the late summer (McMahon 1983a).

### **Habitat Requirements**

Freshwater mussels occur in a variety of habitat types, including both lentic (e.g., lakes, ponds, and reservoirs) and lotic (rivers, streams, and creeks) systems. Habitat preferences tend to be species specific, with unionids generally being most successful and prevalent in stable, coarse sand or sand-gravel mixtures (Way et al. 1990a). Water velocity also plays a critical role in the distribution, diversity, and abundance of mussel populations. Unionids tend to thrive in conditions where water velocities are low enough to allow for substrata stability, but high enough to prevent excessive siltation (Way et al. 1990a). Water velocity also affects the amount of nutrients carried to the filter-feeding organisms. Chemical parameters such as pH and calcium concentrations can influence the distributions of mussel populations as well. The majority of species prefer alkaline water with a pH above 7.0, but unionids can grow and reproduce over a pH range of 5.6-8.3 and can tolerate acidic conditions as low as 4.7 (Okland and Kuiper 1982). Typically, habitats of low pH also have low calcium concentrations. Low calcium concentrations can lead to poor growth and shell dissolution in some individuals, especially if the shell is worn (Kat 1982). Given that growth and dissolution rates are affected by many factors other than pH and calcium concentrations, the minimum tolerable values can vary significantly among habitats. Another important factor to mention in the viability of freshwater mussel populations is the need for suitable host fishes. If the proper host fish is not present for a particular mussel species at any given location, then eventually this species will become extirpated from the site regardless of the habitat conditions.

Sphaeriid clams and Asian clams are generally more tolerant than unionids of what we consider to be harsh conditions. Unlike many unionids, the diversity and abundance of some *Pisidium* and *Sphaerium* species are inversely correlated with substrata size (Kilgour and Mackie 1988), which may be associated with sediment organic feeding mechanisms. *C. fluminea* has a much broader substrata range, and has been seen to successfully colonize habitat consisting of bare rock outcrops to habitat with high silt loads. The highest abundances of *C. fluminea* in North Carolina are often associated with sandy disturbed habitats or with lotic habitats below dams



(J.M. Alderman, NC Wildlife Resources Commission, pers. comm.). Sphaeriids have the ability to colonize ponds and lakes where the depth is greater, the flow is negligible, and the sediment and organic loads are high. Again, this may be associated with feeding mechanisms in sphaeriid clams. Chemical parameters such as pH and calcium concentration regulate sphaeriid clams and *C. fluminea* populations in much the same manner that they affect unionid populations.

### ***Taxonomy, Distributions, and Statuses***

Freshwater mussels are represented worldwide, with North America containing the largest collection, with 297 currently recognized species and subspecies (Williams et al 1993). While unionids are distributed across the entire continent, the greatest diversity lies within the southeastern United States (Neves et al. 1997). North Carolina's share of this diversity is impressive. Once our taxonomic understanding is more complete, approximately 70 species are expected to occur in our state. A significant amount of literature describing site locations for unionids across North America has led to a more refined understanding of the distribution and taxonomy of this fauna.

Of the 297 recognized taxa of freshwater mussels in North America, Williams et al. (1993) recommended that 213 (72%) be considered endangered, threatened, or of special concern. Nearly half of North Carolina's freshwater mussel species are state listed as endangered, threatened, or special concern, and approximately 30% have undetermined statuses (J.M. Alderman, NCWRC, pers. comm.).

Sphaeriid clams are widely distributed and are represented in North America by approximately 37 species. In North Carolina, there are approximately 13 species (Adams 1990). No species are currently listed at this time.

Anthropogenic effects such as siltation, riparian habitat destruction, impoundments, pollution, and hydrologic regime alteration are negatively affecting these taxa. With the introduction of exotic species, such as *C. fluminea*, and the impending introduction of *Dreissena polymorpha* (zebra mussel), the situation continues to worsen. Therefore, it is crucial that nongame biologists continue to gather information pertaining to these organisms so proper management plans can be implemented.

### **Methods**

The freshwater mussel and sphaeriid clam survey of Caswell Game Land was conducted during the summer of 1998. The game land, located in Caswell County, North Carolina, encompasses 16,614 acres. Refer to the Report Introduction for details on history of land use, drainage basin and waterway descriptions, and a map of all the sites that were surveyed. Waterways were accessed at bridge crossings, from which we surveyed mainly upstream for an arbitrary distance (usually 45 minutes of walking). Typical distances were 100 - 400 meters.

Freshwater mussels were collected using a variety of techniques depending on the conditions of the site being surveyed (e.g., water depth, visibility, substrata types). In areas where water clarity allowed, freshwater mussels were collected by viewing the substrata through the water surface with the naked eye. These areas also were snorkeled or surveyed with a viewscope



depending on the depth of the water. In areas that were turbid, freshwater mussels were collected by tactilely surveying suitable habitat. Freshwater mussels also were collected from sites by sieving the substrata through a dip net. If a mussel was located, we typically performed a tactile timed search in the area to determine an approximate abundance at each site. We also noted the type of substrata in which mussel populations colonized to determine if there were any species-specific preferences. Live mussels were identified to species, measured to the nearest mm for length using a Vernier caliper, and returned unharmed to the appropriate habitat. Some individuals were preserved in 70%-denatured ethanol and kept for curation. Shells were collected and identified to species, measured for length (mm), and kept for curation. All common and scientific nomenclature follows Turgeon et al. (1998). Dr. Arthur Bogan of the NC State Museum of Natural Sciences and various NCWRC personnel verified some of the species identifications.

Sphaeriid clams were collected using a variety of methods, including seining, dip netting, and tactile and visual searches. The most prevalent method used was dip netting. This involved running a dip net through vegetation and the substrata to search for the clams. All specimens collected were preserved in 70%-denatured ethanol and identified according to Burch (1975). Specimens also were sent to Dr. Gerald L. Mackie, University of Guelph, Ontario, Canada, for identification confirmation.

## Results

Over 16 days from 18 June to 22 July 1998, 35 sites were surveyed and freshwater mussels were collected at 15 sites (Figure 2 and Table 1). Four species were collected during the survey: *Elliptio complanata*, *Pyganodon cataracta*, *Fusconaia masoni*, and *Strophitus undulatus*. Over this same time period and at the same localities, sphaeriid clams were collected at 10 sites (Figure 3 and Table 2). Of these 10 sites, *Corbicula fluminea* was the only clam present at 8 sites. One pea clam species was collected at the remaining 2 sites: *Sphaerium striatinum*.

*Elliptio complanata* (eastern elliptio) was the most common mussel species found during the Caswell Game Land aquatic inventory. A total of 506 live individuals and 37 shells were collected from 14 sites. Individuals typically were found in the clay banks, with a small percentage residing in sand substratum more in the center of the channel. The flow in these areas tended to be run-like. The average length of the live individuals and the shells was  $89.2 \pm 8.7$  mm and  $92.5 \pm 11.9$  mm, respectively ( $\pm$  SD). The smallest individual collected was a shell measuring 46.0 mm. Time-search abundance estimates of the eastern elliptio ranged from 5 mussels per hour to greater than 200 mussels per hour, with an average of less than 20 per hour.

*Pyganodon cataracta* (eastern floater) was collected at 3 sites during the aquatic inventory. A total of 2 live animals and 3 shells were collected from these sites, with an average length of  $112.2 \pm 24.7$  mm and  $115.0 \pm 3.0$  mm, respectively. The 2 live individuals were found in sand/pebble/gravel substratum with a run-slack flow regime.

*Strophitus undulatus* (creeper) was found at 2 localities, with only a single live individual collected at site 980624.1. This individual was found under a rock in a riffle comprised of sand/pebble/gravel substrata. Additional tactile and visual timed searches at this same location failed to produce any other specimens. The specimen was only 35.0 mm long, which indicated



that reproduction was relatively recent and that additional individuals were probably present. In addition, 3 shells were collected between the 2 sites with an average length of  $42.3 \pm 27.6$  mm.

*Fusconaia masoni* (Atlantic pigtoe) was found at a single location in Country Line Creek. The individual was 59.0 mm long and was very worn. At the time this animal was collected, we did not realize that it was different from the *Elliptio complanata* that we had collected due to the wear and unusual shape of the shell, so the habitat it resided in is unknown. Overall, the substrata at this site are dominated by sand with clay banks, so it was most likely found in sand or along the edge of the clay banks with a moderate to slow flow. Johnson (1970) associated this species with sand substratum.

*Sphaerium striatinum* (striated fingernailclam) was collected from 2 sites during the aquatic inventory. Eleven live striated fingernail clams were collected in Country Line Creek, while 1 live *S. striatinum* was found in Kilgore Creek. All individuals were found in sand with a run-slack flow regime.

## Discussion

The overall diversity of the freshwater mussel fauna in Caswell Game Land and its associated waterways is low. The waterways of the game land provided habitat for only 4 of the 14 species noted by J.M. Alderman (NCWRC, pers. comm.) as being present in the Roanoke River Basin of the southern Atlantic Slope region. While water chemistry parameters were not measured at the surveyed sites, the most likely reason for low unionid diversity probably was due to cumulative impacts from decades of poor land and water uses.

Overall, the substrata in the waterways surveyed were relatively homogenous, with sand dominating the streams. The water depth and flow regime in the waterways also was monotypic, with most streams exhibiting shallow and slow flowing conditions. Freshwater mussels are typically more successful in areas with differing or diverse habitat types (see Background, Habitat Requirements).

Additionally, the abundance and distribution of each species was low, with *P. cataracta*, *S. undulatus*, and *F. masoni* being represented by less than 3 live individuals each at a total of 5 sites. *Elliptio complanata* was more widely distributed, with live individuals collected at 14 sites, but the abundance at most of those sites was low. Typically, we found less than 20 individuals during a 1-hour time search at each site and these individuals would be extremely patchy. Evidence of reproduction was nonexistent with most of the species collected. A single *S. undulatus* shell and live individual measuring 23.0 mm and 35.0 mm, respectively, were the only evidence of recent reproduction. Given the diverse fish fauna found during the survey, one might assume that evidence of recent reproduction would be more prevalent. Visual and tactile searches in areas with low abundance of mussels and with mussel populations having patchy distributions are the best methods for finding specimens >20 mm in length. Therefore, we should have turned up some live juveniles or young mussels, or shells of these young animals if they were present. We cannot explain the evidence suggesting limited successful reproduction in these populations.

The collection of *Fusconaia masoni* in Country Line Creek is a significant addition to the distribution of this species within North Carolina. Current records indicate that this is only the second known locality of this species within the Roanoke River Basin in North Carolina (J.M. Alderman, NCWRC, pers. comm.). Additionally, this species is currently state-listed threatened (proposed as endangered) and is a federal species of concern. A more intensive survey of Country Line Creek and its associated tributaries should be conducted to more thoroughly document the status of the Atlantic pigtoe.



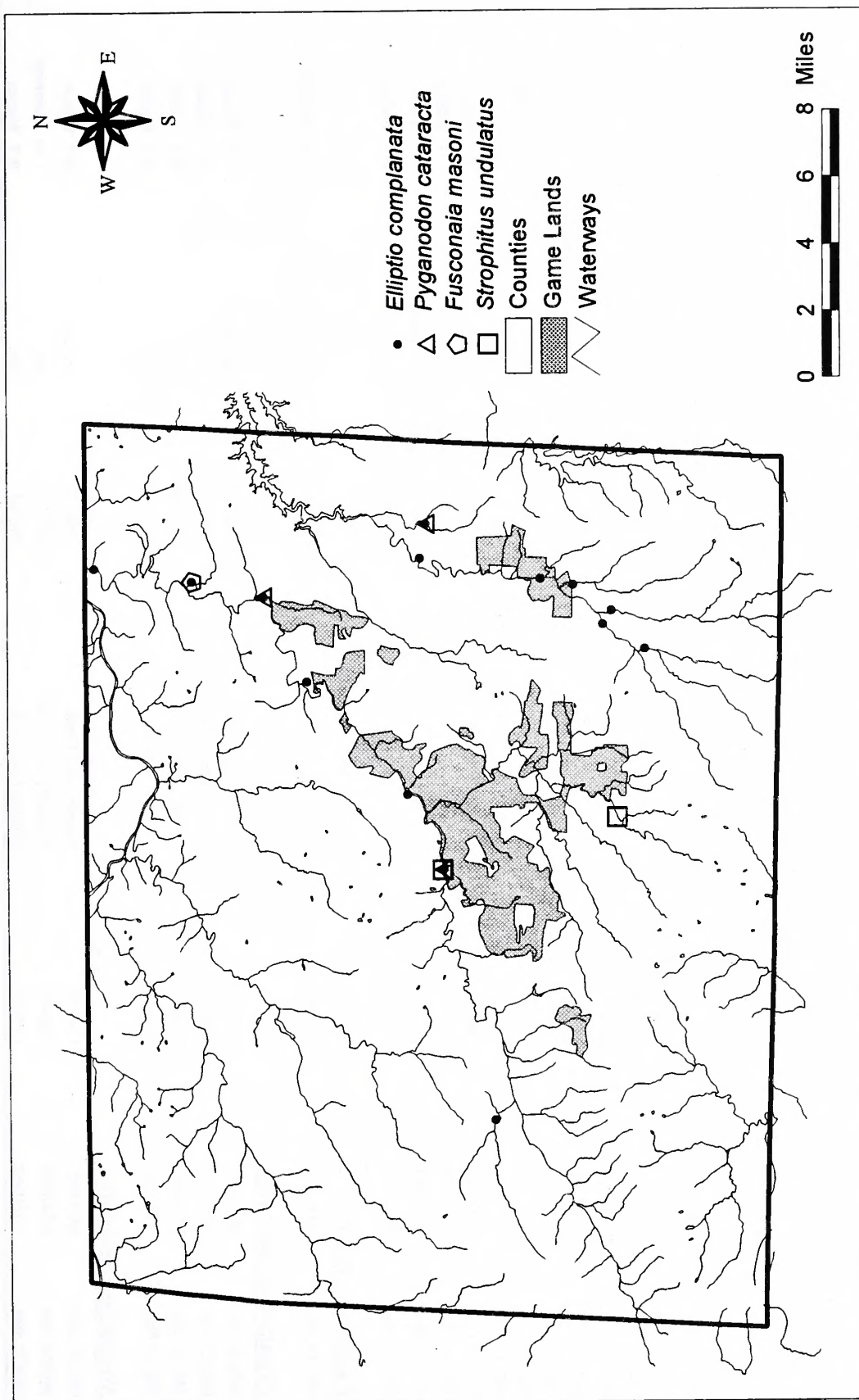


Figure 2. Map of sites indicating where each species of freshwater mussel was collected in the Caswell Game Land aquatic inventory, Caswell County, North Carolina, 1998.



Table 1. Freshwater mussel species found in Caswell Game Land associated waterways. See text for common names.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<b><u>Elliptio complanata</u></b>						
980610.5bw	6/10/1998	Caswell	Hycro Creek	SR 1710	present	B.T. Watson
980610.6bw	6/10/1998	Caswell	Panther Creek	SR 1723	present	B.T. Watson
980610.7bw	6/10/1998	Caswell	Lynch Creek	SR 1723	present	B.T. Watson
980618.1bw	6/18/1998	Caswell	Hycro Creek	SR 1710	patchy common	B.T. Watson
980623.1bw	6/23/1998	Caswell	Lynch Creek	SR 1723	patchy uncommon	B.T. Watson
980625.3bw	6/25/1998	Caswell	Country Line Creek	NC 62	patchy uncommon	B.T. Watson
980629.1bw	6/29/1998	Caswell	Panther Creek	SR 1723	rare	B.T. Watson
980629.3bw	6/29/1998	Caswell	Trib to Hycro Creek (Negro Ck?)	SR 1765	rare	B.T. Watson
980702.3bw	7/2/1998	Caswell	Hycro Creek	NC 86, SR 1786	patchy common	B.T. Watson
980707.1bw	7/7/1998	Caswell	Hycro Creek	US 158	abundant	B.T. Watson
980707.2bw	7/7/1998	Caswell	Kilgore Creek	US 158	rare	B.T. Watson
980709.1bw	7/9/1998	Caswell	Hostettler Branch	NC 150	rare	B.T. Watson
980714.1bw	7/14/1998	Caswell	Country Line Creek	SR 1554	rare	B.T. Watson
980715.1bw	7/15/1998	Caswell	Country Line Creek	1780	rare	B.T. Watson
980715.3bw	7/15/1998	Caswell	Country Line Creek	NC 57	rare	B.T. Watson
980715.4bw	7/15/1998	Caswell	Country Line Creek	SR 1565	uncommon	B.T. Watson
980716.1bw	7/16/1998	Caswell	Country Line Creek	SR 1597	rare	B.T. Watson
<b><u>Fusconaia masoni</u></b>						
980714.1bw	7/14/1998	Caswell	Country Line Creek	SR 1554	rare	J.M. Alderman
<b><u>Pyganodon cataracta</u></b>						
980609.2bw	6/9/1998	Caswell	Country Line Creek	Hwy 62	present	B.T. Watson
980625.3bw	6/25/1998	Caswell	Country Line Creek	NC 62	rare	B.T. Watson
980707.2bw	7/7/1998	Caswell	Kilgore Creek	US 158	rare	B.T. Watson
980715.4bw	7/15/1998	Caswell	Country Line Creek	SR 1565	rare	B.T. Watson
<b><u>Strophitus undulatus</u></b>						
980609.2bw	6/9/1998	Caswell	Country Line Creek	Hwy 62	present	B.T. Watson
980624.1bw	6/24/1998	Caswell	S Country Line Creek	SR 1759	rare	J. M. Alderman
980625.3bw	6/25/1998	Caswell	Country Line Creek	NC 62	rare	B.T. Watson

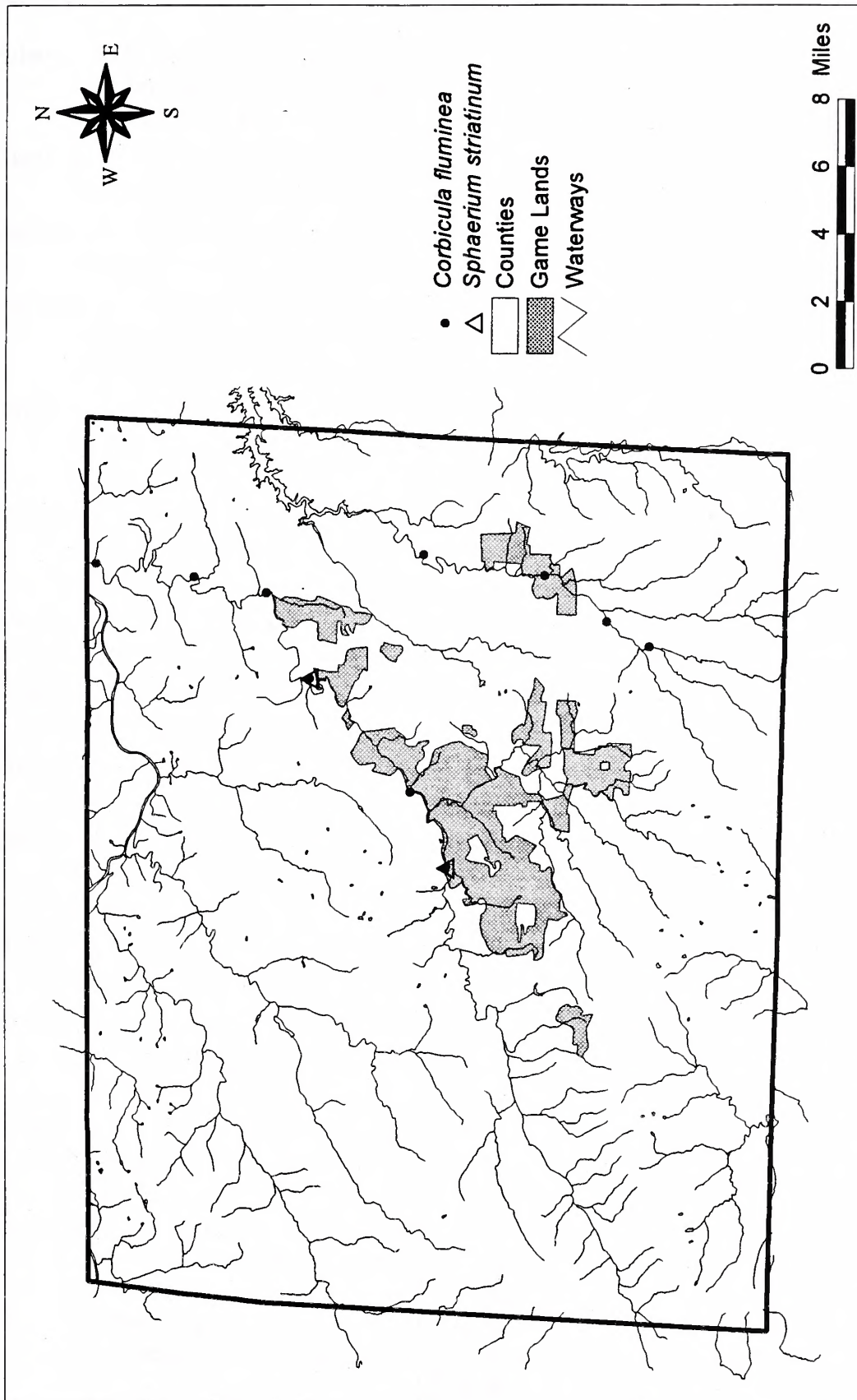


Figure 3. Map of sites indicating where each species of sphaeriid clam was collected in the Caswell Game Land aquatic inventory, Caswell County, North Carolina, 1998.

Table 2. Sphaeriid clam species and *C. fluminea* found in Caswell Game Land associated waterways. See text for common names.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<b><u>Corbicula fluminea</u></b>						
980609.2bw	6/9/1998	Caswell	Country Line Creek	Hwy 62	common	B.T. Watson
980618.1bw	6/18/1998	Caswell	Hycoc Creek	SR 1710	common	B.T. Watson
980625.3bw	6/25/1998	Caswell	Country Line Creek	NC 62	abundant	B.T. Watson
980629.3bw	6/29/1998	Caswell	Trib to Hycoc Creek (Negro Ck?)	SR 1765	rare	B.T. Watson
980702.3bw	7/2/1998	Caswell	N Hycoc Creek	NC 86, SR1786	common	B.T. Watson
980707.1bw	7/7/1998	Caswell	Hycoc Creek	US 158	common	B.T. Watson
980714.1bw	7/14/1998	Caswell	Country Line Creek	SR 1554	common	B.T. Watson
980715.1bw	7/15/1998	Caswell	Country Line Creek	1780	common	B.T. Watson
980715.3bw	7/15/1998	Caswell	Country Line Creek	NC 57	abundant	B.T. Watson
980715.4bw	7/15/1998	Caswell	Country Line Creek	SR 1565	common	B.T. Watson
980716.1bw	7/16/1998	Caswell	Country Line Creek	SR 1597	patchy uncommon	B.T. Watson
<b><u>Sphaerium striatinum</u></b>						
980609.2bw	6/9/1998	Caswell	Country Line Creek	Hwy 62	rare	B.T. Watson
980716.1bw	7/16/1998	Caswell	Country Line Creek	SR 1597	patchy common	B.T. Watson, G.L. Mackie



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# AQUATIC SNAILS

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## Introduction

Freshwater snails (Mollusca: Gastropoda) are among the most ubiquitous organisms of shallow littoral zones in lakes and streams. Due to their behavior, widespread distribution, and commonly high abundance, snails serve a number of important roles in the aquatic ecosystem. These include driving predator-prey interactions (Vermeij and Covich 1978), serving as a dietary component to fish and wildlife, acting as water quality indicators, and most importantly, grazing on nuisance algae and detritus. However, freshwater snails are often overlooked due in part to their small size, perceived lack of charisma, cryptic habits, and the lack of readily available comprehensive guides for identification. As part of the inventory of aquatic animals associated with the state-owned Caswell Game Land, we conducted field surveys of aquatic snails found in waterways occurring in and around the game land to better understand the taxonomy, distribution, and conservation needs of the taxa in North Carolina.

## Life History

Much information about the reproductive cycles of freshwater snails has been ascertained due to the ease of laboratory rearing. From this information, 2 typical categories have been developed in which snails can be placed reproductively (Russell-Hunter 1978, Calow 1978). The first category includes annual adults that reproduce in the spring and die (semelparous). Most pulmonates (lung-breathing), which are oviparous hermaphrodites, belong to this group including the genera *Lymnaea* and *Physa*. The second category includes perennial adults that reproduce in both spring and late summer. Most prosobranchs (gill-breathing), which are dioecious and can be oviparous or ovoviviparous, belong to this group. These species are iteroparous and often live and reproduce for 4-5 years. Prosobranchs also are often sexually dimorphic, with females living longer than males (Brown et al. 1989).

## Habitat and Food Requirements

Freshwater snails occur in a variety of habitat types, including both lentic (e.g., lakes, ponds, and reservoirs) and lotic (e.g., rivers, streams, and creeks) systems. Habitat preferences tend to be species specific, with substratum selection well documented (Brown 1991). In general, slow-moving, silty habitats are colonized predominately by pulmonates or detritivorous prosobranchs, whereas limpets or prosobranch grazers colonize fast-current localities (Harman 1972). Many biotic and abiotic factors regulate the distribution of freshwater snails, with water hardness and pH considered as the major determinants (Macan 1950, Pip 1986). However, it has been suggested that physiochemical factors such as calcium concentrations may only act to limit successful invasion of habitats with extreme levels of these factors (Lodge et al. 1987). Other factors such as dispersal ability and adequate substrata may play a more prominent role in snail distribution.



Freshwater snails are predominantly herbivores or detritivores, although they can ingest carrion (Bovbjerg 1968) or passively consume small invertebrates associated with periphyton (Coker 1983a). Apparently, they prefer periphyton because it is easier to scrape than macrophytes and it contains higher concentrations of nitrogen and other limiting nutrients (Russell-Hunter 1978, Aldridge 1983). Algae and diatoms also are a prominent source of nutrients for freshwater snails (Lodge 1986). While macrophytes are not the preferred source of nutrients for most freshwater snails, significant consumption can occur if snail densities reach high levels (Sheldon 1987).

### ***Taxonomy, Distribution, and Statuses***

Freshwater snails are divided into 2 groups – prosobranchs and pulmonates. Prosobranch snails are gill-breathing and have a calcareous plate called an operculum that seals the aperture when the snail withdraws into its shell. Pulmonate snails are lung-breathing and lack an operculum. Of the approximately 500 species recognized in North America, there are 49 genera and 349 species of prosobranch snails and 29 genera and 150 species of pulmonate snails (Burch 1982). While snails are widespread across the continents, they have reached their greatest abundance and diversity within the streams of the southeastern United States (Brown 1991). In North Carolina, there are approximately 52 species representing 10 families (Bogan 1997). Since very little work has been done to monitor freshwater snail populations, the current status of many species within North Carolina is undetermined. It is unknown as to the magnitude of impact that anthropogenic effects such as siltation, riparian habitat destruction, impoundments, pollution, and hydrologic regime alteration have had on the state's snail fauna. Therefore, it is crucial that nongame biologists continue to gather information pertaining to these organisms so proper management plans can be implemented.

### **Methods**

The freshwater snail survey of Caswell Game Land was conducted during the summer of 1998. The game land, located in Caswell County, North Carolina, encompasses 16,614 acres. Refer to the Report Introduction for details on history of land use, drainage basin and waterway descriptions, and a map of all the sites that were surveyed. Waterways were accessed at bridge crossings, from which we surveyed mainly upstream for an arbitrary distance (usually 45 minutes of walking). Typical distances were 100 - 400 meters.

Freshwater snails were collected using a variety of techniques depending on the conditions of the site being surveyed (e.g., water depth, visibility, substrata types). The most common methods used to sample the snail fauna were visual searches and dip netting. The visual search basically involved examining woody debris, vegetation, cans and bottles, and other items that snails might colonize. Dip netting involved running a 1/8-inch mesh dip net through vegetation and the substrata to collect snails. Other techniques used to collect snails included tactile searches, snorkeling, and the use of a viewscope. Habitat preference, relative abundance, and recent reproduction for snail species were noted at each site. Snails were preserved in 70%-denatured alcohol and identified according to Burch (1989) and Bausch (1963). Scientific names are according to Turgeon et al. (1998). Dr. Arthur Bogan of the NC State Museum of Natural Sciences and various NCWRC personnel verified some of the species identifications. Not all snails collected were preserved for obvious conservation and ethical reasons.



## Results

Over 16 days from 18 June to 22 July 1998, 35 sites were inventoried and snails were collected or observed at 27 of these localities (Figures 4a and 4b). Eight species representing 6 families were documented during the survey of Caswell Game Land (Tables 3 and 4). The relative abundance of each species was fairly low, with *Physella* sp. and *Ferrissia rivularis* seemingly the most dominate snails in the survey area. These 2 species also were the most widespread with each being collected at 19 and 12 sites, respectively. The remaining snail species were represented at a low number of sites, ranging from 3-6, and they were mostly uncommon to rare. *Elimia symmetrica* was the only species that was abundant while not having a widespread distribution. Recent reproduction was seen at a number of sites for *Physella* sp., *Pseudosuccinea columella*, *E. symmetrica*, *Cameloma decisum*, *Helisoma anceps*, and *Ferrissia rivularis*.

*Physella* sp. (physa snail), *C. decisum* (pointed campeloma), *P. columella* (mimic lymnaea), and *H. anceps* (two-ridge rams-horn) tended to inhabit areas with slow flow, which included backwater areas, along the stream bank, and behind sand bars. *C. decisum* was found predominantly in sand and detritus, but occasionally, an individual was found on the clay banks or on woody debris or vegetation. *Physella* sp. and *P. columella* were typically found along the clay banks and occasionally on aquatic vegetation and woody debris with *H. anceps*. *Micromenetus dilatatus* (bugle sprite) and *F. rivularis* (creeping ancyloid) were typically found in areas with slow to moderate flow on aquatic vegetation and woody debris. These two species also were found on cans and bottles, with *F. rivularis* being especially common on these items. *E. symmetrica* (symmetrical elimia) was predominantly found in areas of moderate to fast flow and were congregated on pebble and gravel. A habitat preference for *Fossaria obrussa* (golden fossaria) was not noted due to the limited number we collected and not knowing the substratum we were collecting them from. However, they most likely reside on aquatic vegetation and woody debris in areas of slow to moderate flow as we have seen in other localities in the state.

## Discussion

Overall, the diversity and abundance of freshwater snails in waterways associated with Caswell Game Land are moderate. Comparisons to other waterways within the Roanoke drainage are uncertain due to a lack of recent surveys. Given the homogeneity of the habitat and flow regime encountered, it is likely that these factors have significantly influenced the current status of the snail fauna associated with Caswell Game Land. The typical stream that we encountered during our survey was dominated by sand and clay banks, had a slow flow, and was less than 2 feet deep for approximately 75% of the sampled reaches. Woody debris and vegetation also were uncommon to moderate in most of the streams, which are significant refugia and nutrients for a majority of snails. No significant distribution trends were seen, as most of the individuals encountered were located in Country Line Creek Subbasin and Hyco Creek Subbasin. However, *C. decisum*, *E. symmetrica*, and *M. dilatatus* were limited to Country Line Creek drainage most likely due to dispersal patterns. These animals also may have been eliminated from some streams due to past land and water uses, just as with mussels. During the 1800s, some North Carolina counties had about 90% of the landscape in agriculture. Therefore, many of these creeks and streams were heavily impacted by sedimentation.

Taxonomic uncertainties within the freshwater snail fauna make the results here subject to revision. For example, there has been a long-standing debate among malacologists as to the correct taxonomy of the Pleuroceridae, with some people using the genus *Goniobasus* and some using *Elimia*. Likewise, the differentiation between *F. rivularis* and *F. fragilis* is difficult. The most common factor used to distinguish these species is the habitat they are collected in, with *F. rivularis* colonizing rivers and streams and *F. fragilis* inhabiting stagnant areas such as ditches, ponds, and backwater areas. All of the limpets identified in this survey were assigned to *F. rivularis*, but it is likely that *F. fragilis* was found or does inhabit some of the sites that were surveyed. Likewise, there is uncertainty as to the taxonomic assignments within the *Campeloma* genera, and the identification of hybriids is only certain by examining penile structure (Burch 1989).

No rare or significant snail species were found during the Caswell Game Land aquatic inventory. However, much more research and status surveys are needed to determine which species are significant or rare on a statewide basis. Current land management practices, including agriculture and urbanization, are having an effect on the snail fauna in North Carolina. As nongame biologists, we need to identify which species are at risk and identify ways to reduce or eliminate impacts.



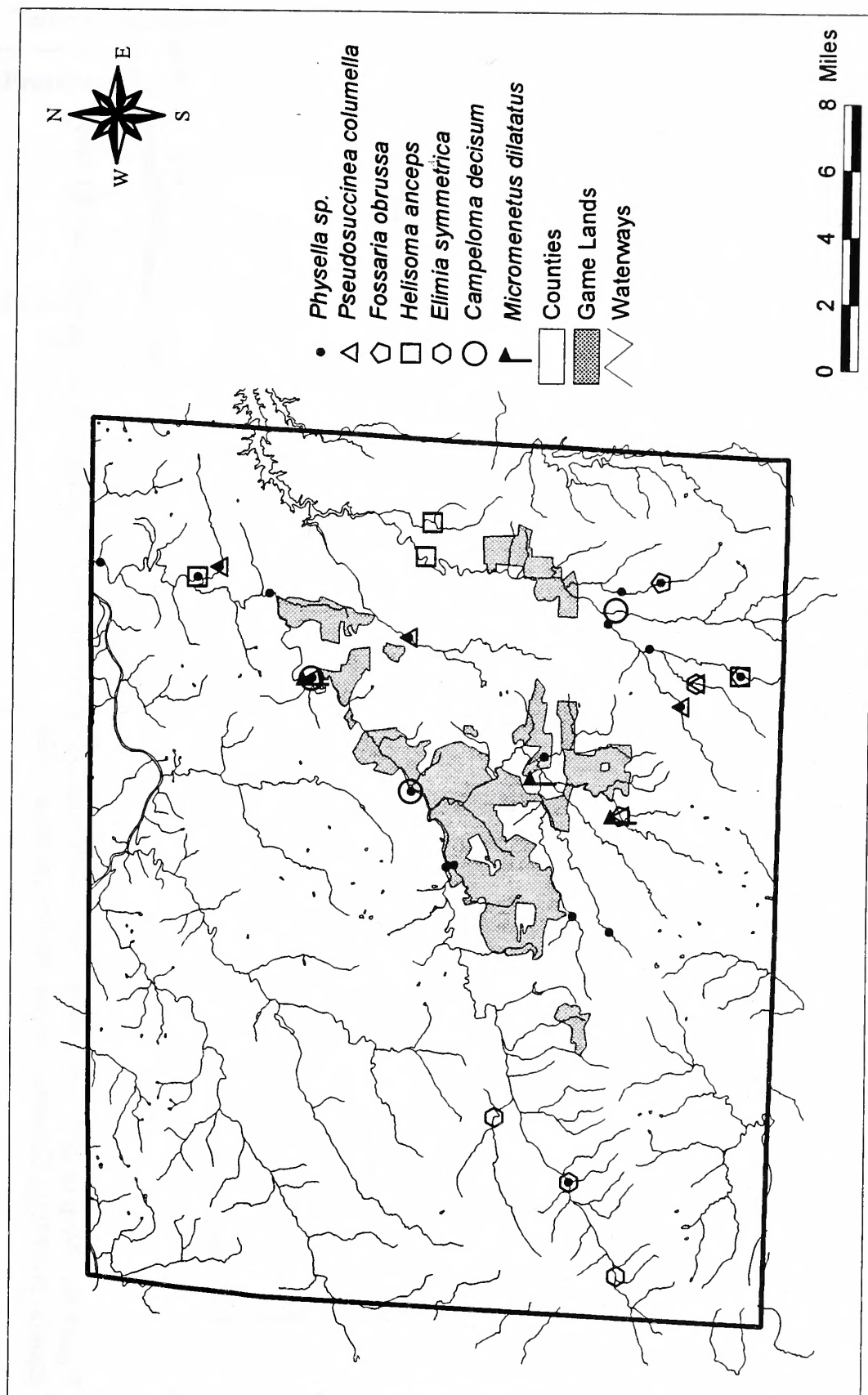


Figure 4a. Map of sites indicating where each species of snail was collected in the Caswell Game Land aquatic inventory, Caswell County, North Carolina, 1998.

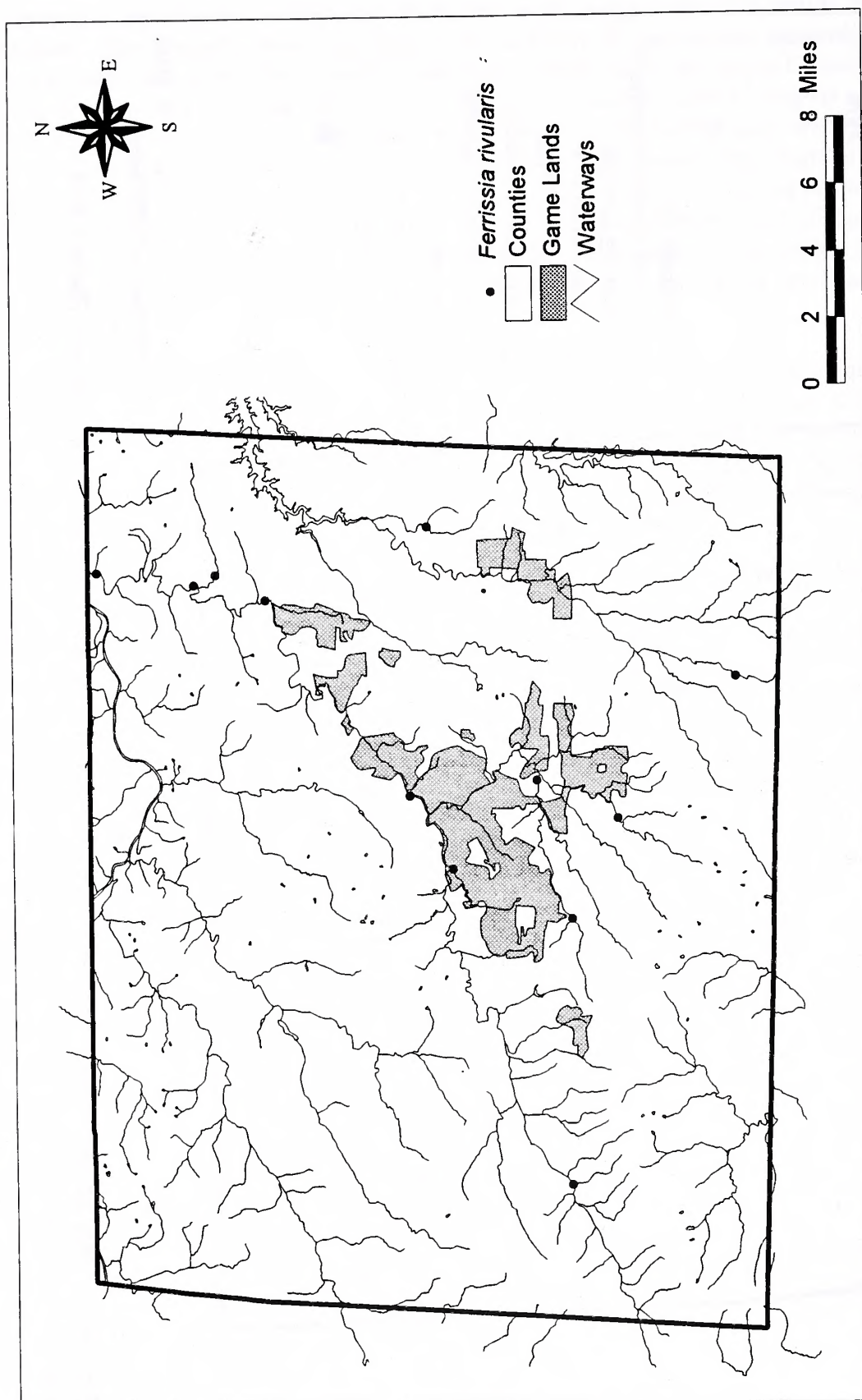


Figure 4b. Map of sites indicating where each species of ancylid was collected in the Caswell Game Land aquatic inventory, Caswell County, North Carolina, 1998.

Table 3. Aquatic snail species found in Caswell Game Land associated waterways.

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**Prosobranchia**

Pleuroceridae

*Elimia symmetrica*

Symmetrical elimia

Viviparidae

*Campeloma decisum*

Pointed campeloma

**Pulmonata**

Ancylidae

*Ferrissia rivularis*

Creeping ancylid

Lymnaeidae

*Fossaria obrussa*

Golden fossaria

*Psuedosuccinea columella*

Mimic lymnaea

Physidae

*Physella* sp.

Physa snail

Planorbidae

*Helisoma anceps*

Two-ridge rams-horn

*Micromenetus dilatatus*

Bugle sprite

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Table 4. Aquatic snail species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<u><i>Campeloma decisum</i></u>						
980623.1bw	6/23/1998	Caswell	Lynch Creek	SR 1723	patchy uncommon	B.T. Watson
980715.1bw	7/15/1998	Caswell	Country Line Creek	1780	rare	B.T. Watson
980716.1bw	7/16/1998	Caswell	Country Line Creek	SR 1597	patchy common	B.T. Watson
<u><i>Elimia symmetrica</i></u>						
980625.1bw	6/25/1998	Caswell	Country Line Creek	SR 1146	patchy abundant	B.T. Watson, A.E. Bogan
980625.2bw	6/25/1998	Caswell	Country Line Creek	SR 1129	patchy uncommon	B.T. Watson, A.E. Bogan
980701.1bw	7/1/1998	Caswell	Negro Creek	SR 1767	patchy common	B.T. Watson, A.E. Bogan
980709.1bw	7/9/1998	Caswell	Hostettler Branch	NC 150	patchy abundant	B.T. Watson, A.E. Bogan
<u><i>Ferrissia rivularis</i></u>						
980624.4bw	6/24/1998	Caswell	Penson Creek	SR 1783	rare	B.T. Watson
980707.2bw	7/7/1998	Caswell	Kilgore Creek	US 158	patchy common	B.T. Watson
980708.1bw	7/8/1998	Caswell	Penson Creek	SR 1736	patchy common	B.T. Watson
980708.3bw	7/8/1998	Caswell	South Country Line Creek	SR 1759	patchy uncommon	B.T. Watson
980709.3bw	7/9/1998	Caswell	Benay Creek	NC 62	patchy common	B.T. Watson
980714.1bw	7/14/1998	Caswell	Country Line Creek	SR 1554	patchy common	B.T. Watson
980714.2bw	7/14/1998	Caswell	Kilgore Creek	SR 1557	rare	B.T. Watson
980715.1bw	7/15/1998	Caswell	Country Line Creek	1780	uncommon	B.T. Watson
980715.3bw	7/15/1998	Caswell	Country Line Creek	NC 57	rare	B.T. Watson
980715.4bw	7/15/1998	Caswell	Country Line Creek	SR 1565	rare	B.T. Watson
980716.2bw	7/16/1998	Caswell	Trib to Hyco Creek	SR 1767	rare	B.T. Watson
980722.2bw	7/22/1998	Caswell	Country Line Creek	SR 1129	patchy uncommon	B.T. Watson
<u><i>Fossaria obrussa</i></u>						
980702.1bw	7/2/1998	Caswell	Trib to Panther Creek	SR 1774/1775	rare	B.T. Watson, A.E. Bogan
980708.3bw	7/8/1998	Caswell	South Country Line Creek	SR 1759	rare	B.T. Watson, A.E. Bogan
980716.2bw	7/16/1998	Caswell	Trib to Hyco Creek	SR 1767	rare	B.T. Watson, A.E. Bogan

Table 4 (cont.). Aquatic snail species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<b><u>Helisoma anceps</u></b>						
980707.1bw	7/7/1998	Caswell	Hycro Creek	US 158	rare	B.T. Watson, A.E. Bogan
980707.2bw	7/7/1998	Caswell	Kilgore Creek	US 158	patchy common	B.T. Watson, A.E. Bogan
980714.1bw	7/14/1998	Caswell	Country Line Creek	SR 1554	rare	B.T. Watson
980716.2bw	7/16/1998	Caswell	Trib to Hycro Creek	SR 1767	rare	B.T. Watson
<b><u>Micromenetus dilatatus</u></b>						
980708.1bw	7/8/1998	Caswell	Penson Creek	SR 1736	rare	B.T. Watson, A.E. Bogan
980708.3bw	7/8/1998	Caswell	South Country Line Creek	SR 1759	rare	B.T. Watson, A.E. Bogan
980716.1bw	7/16/1998	Caswell	Country Line Creek	SR 1597	rare	B.T. Watson, A.E. Bogan
<b><u>Physella sp.</u></b>						
980624.3bw	6/24/1998	Caswell	Burkes Creek	SR 1732	patchy rare	B.T. Watson
980624.4bw	6/24/1998	Caswell	Penson Creek	SR 1783	patchy common	B.T. Watson
980625.2bw	6/25/1998	Caswell	Country Line Creek	SR 1129	rare	B.T. Watson
980625.3bw	6/25/1998	Caswell	Country Line Creek	NC 62	patchy rare	B.T. Watson
980629.2bw	6/29/1998	Caswell	N Hycro Creek	SR 1767	patchy rare	B.T. Watson
980629.3bw	6/29/1998	Caswell	Trib to Hycro Creek (Negro Ck?)	SR 1765	rare	B.T. Watson
980702.1bw	7/2/1998	Caswell	Trib to Panther Creek	SR 1774/1775	common	B.T. Watson
980702.2bw	7/2/1998	Caswell	Trib to Panther Creek	SR 1722	patchy uncommon	B.T. Watson
980702.3bw	7/2/1998	Caswell	N Hycro Creek	NC 86, SR1786	patchy common	B.T. Watson
980707.3bw	7/7/1998	Caswell	Reedy Fork	US 158	patchy common	B.T. Watson
980709.2bw	7/9/1998	Caswell	Trib to S Country Line Creek	SR 1730	rare	B.T. Watson
980709.3bw	7/9/1998	Caswell	Benay Creek	NC 62	patchy common	B.T. Watson
980714.1bw	7/14/1998	Caswell	Country Line Creek	SR 1554	patchy uncommon	B.T. Watson
980714.2bw	7/14/1998	Caswell	Kilgore Creek	SR 1557	rare	B.T. Watson
980715.1bw	7/15/1998	Caswell	Country Line Creek	1780	common	B.T. Watson
980715.3bw	7/15/1998	Caswell	Country Line Creek	NC 57	patchy uncommon	B.T. Watson
980715.4bw	7/15/1998	Caswell	Country Line Creek	SR 1565	patchy uncommon	B.T. Watson
980716.1bw	7/16/1998	Caswell	Country Line Creek	SR 1597	common	B.T. Watson
980716.2bw	7/16/1998	Caswell	Trib to Hycro Creek	SR 1767	rare	B.T. Watson



Table 4 (cont.). Aquatic snail species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<i>Pseudosuccinea columella</i>						
980629.2bw	6/29/1998	Caswell	N Hyco Creek	SR 1767	patchy rare	B.T. Watson
980701.1bw	7/1/1998	Caswell	Negro Creek	SR 1767	rare	B.T. Watson
980707.3bw	7/7/1998	Caswell	Reedy Fork	US 158	patchy common	B.T. Watson
980708.3bw	7/8/1998	Caswell	South Country Line Creek	SR 1759	patchy uncommon	B.T. Watson
980714.2bw	7/14/1998	Caswell	Kilgore Creek	SR 1557	rare	B.T. Watson
980716.1bw	7/16/1998	Caswell	Country Line Creek	SR 1597	rare	B.T. Watson

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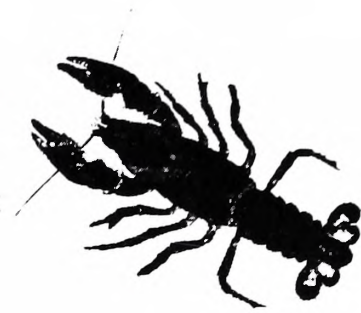
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# CRAYFISH

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## Introduction

Crayfish play important roles in aquatic and sometimes terrestrial ecosystems, both as food sources for many animals and also as consumers of plant and animal material. Despite the magnitude of their ecological roles, we have much to learn about crayfish distributions, life histories, and taxonomy. As part of the inventory of aquatic animals associated with the state-owned Caswell Game Land, we conducted field surveys of the crayfishes found in waterways occurring in and around the game land to contribute to our understanding of the distribution and status of crayfishes in North Carolina.

## *Reproduction and Life History*

The crayfishes that occur in North Carolina (all members of the family Cambaridae) live for 2-3 years, on average (Hobbs III 1991, Taylor et al. 1996). Energy obtained from food consumption is allocated largely toward growth as juveniles and toward reproduction as adults (DiStefano 1993). Growth is accomplished through a series of exoskeletal molts (a process known as ecdysis), numbering from 5-10 until adulthood is reached, followed by only 1 (females) or 2 (males) molts per year on average throughout adulthood (Hobbs III 1991, DiStefano 1993). Male cambarid crayfishes exhibit cyclic dimorphism, alternating between a reproductively active form (Form I) and a non-reproductive form (Form II). Form I males can be present all year, but are usually most abundant during the fall and/or spring. Females carry fertilized eggs attached to their abdomens (a condition that is termed "in berry") for 2-20 weeks, depending on water temperatures. Once hatched, the juveniles are carried on the female until they molt into the 3rd instar (on average), after which they are free-living. Cambarid crayfishes breed more than once during their lives (Hobbs III 1991, DiStefano 1993).

## *Habitat Requirements and Preferences*

Crayfish occur in lentic (e.g., lakes, ponds, marshes, ditches, backwaters of large rivers, groundwater) and lotic (e.g., streams, rivers, groundwater) aquatic habitats ranging from oligotrophic to hypereutrophic (Hobbs III 1991). Crayfish can be further classified as hypogean (below-ground dwellers) or epigean (above-ground dwellers). Hypogean crayfish spend much of their time in elaborate underground burrows associated with groundwater. These burrows can be in close proximity to a water body or stream, but also can be situated far from open water. Depending on the amount of time spent underground and the extent of tunnels created, burrowing crayfish are classified as primary, secondary, or tertiary burrowers (Hobbs III 1991). Generally, epigean crayfish occur in shallow (1-2 m) water, but can occur in deeper water, especially as adults. Juveniles are often found in littoral areas, where adequate shelter provides



protection from predation and may mediate competition with adults. Crayfish actively forage at night, but seek shelter from predators during daylight in aquatic macrophytes, leaf litter, woody debris, overhanging roots, cobble or large boulders, burrows or depressions, and in human debris (e.g., cans, tires) (Lodge and Hill 1994).

Crayfish are affected by both water and habitat quality. Changes in water quality that interfere with respiration (e.g., drastic temperature changes, acidification, pollution) can be detrimental to crayfish populations. Many crayfish are oxygen regulators and can survive changes in oxygen levels (Reiber 1995), but some are oxygen conformers and are less likely to successfully contend with these changes (Hobbs III 1991). Water pollution, caused by sources such as sewage, agricultural and urban runoff, acidification, and auto exhaust, can result in bioaccumulation of pesticides and trace heavy metals (e.g., lead, copper, cadmium). This can harm animals that consume crayfish in addition to directly causing negative effects on crayfish (e.g., mutation, reproductive failure, death) (Taylor et al. 1995, Daveikis and Alikham 1996, Anderson et al. 1997, Zaranko et al. 1997). Habitat destruction also can negatively affect crayfish populations. Land use practices (e.g., agriculture, logging, and development) can alter habitat resulting in fewer areas available as shelter to crayfish (Smith et al. 1996, Richter et al. 1997). For example, siltation and runoff can decrease macrophyte (a source of food and shelter) availability and channelization can alter stream bed sculpture.

### *Ecological Interactions*

Crayfish are directly and indirectly linked to the ecosystems in which they live. Because they are omnivorous (i.e., consume both plant and animal food, living or dead), and because they are consumed by animals from various trophic levels, crayfish form multiple links in aquatic and terrestrial food webs (Lodge et al. 1994, Charlebois and Lamberti 1996, Nystrom et al. 1996). Thus, crayfish are involved in the transfer of large amounts of energy in these systems. Crayfish process nutrients and make them available to other animals by (1) breaking down large material via shredding into sizes usable by other animals, and (2) converting nutrients into biomass. Crayfish feed on aquatic vegetation (e.g., macrophytes, algae, periphyton), macroinvertebrates (e.g., aquatic insects, mollusks, small crustaceans), and small vertebrates (e.g., amphibians, small/juvenile fish). Crayfish also consume non-living organic matter such as leaf litter or terrestrial animal carcasses from the riparian zone or shore and decaying aquatic plant and animal matter (Lodge and Hill 1994). Crayfish in turn are consumed by invertebrates (including other crayfish), fish, amphibians, reptiles, birds, and mammals (Lodge and Hill 1994).

Crayfish also experience competition, both between species and among different sizes of individuals within a population (Lodge and Hill 1994). The introduction of non-indigenous species to areas currently occupied by native crayfish can result in competition or even extirpation of natives and also can have impacts on other components of the ecosystem (Charlebois and Lamberti 1996, Perry 1998). For example, if crayfish become too abundant, they can be destructive to aquatic ecosystems by destroying more macrophytes than they consume, resulting in less habitat and food for other animals (Lodge et al. 1994, Nystrom et al. 1996). Crayfish also perform an important role as a member of symbiosis with many invertebrates and as host to various aquatic parasites (Lodge and Hill 1994).



## ***Taxonomy, Distribution, and Statuses***

In the United States and Canada, approximately 350 taxa of crayfish are recognized (Taylor et al. 1996, J.E. Cooper, pers. comm.). However, many species still await description (J.E. Cooper, pers. comm.). For example, several current species are now recognized to be species complexes consisting of more than a single taxon. Conversely, animals grouped into several species or subspecies by different authors may actually belong to the same species. The greatest diversity of crayfishes occurs in the Southeast (Hobbs III 1991, Taylor et al. 1996), and North Carolina harbors at least 33 (possibly up to 46) native and 2 introduced species of *Cambarus*, *Procambarus*, *Orconectes*, and *Fallicambarus* (Cooper and Braswell 1995, J.E. Cooper, pers. comm.). About half of North Carolina's described crayfishes are of undetermined conservation status (Adams 1992), and perhaps as many as a dozen native species are yet to be described (J.E. Cooper, pers. comm.). Of those species for which we have at least some information, the North Carolina Natural Heritage Program lists 10 species as significantly rare (LeGrand and Hall 1998). New information about current distributions has recently been reported (Cooper and Braswell 1995, Cooper et al. 1998). However, given that undescribed species exist and that we have much to learn about the distributions of crayfishes in North Carolina, it is imperative that we continue to improve our knowledge of crayfish by contributing to the growing database.

## **Methods**

The crayfish survey of Caswell Game Land was conducted during the summer of 1998. The game land, located in Caswell County, North Carolina, encompasses 16,614 acres. Refer to the Report Introduction for details on history of land use, drainage basin and waterway descriptions, and a map of all the sites that were surveyed. Waterways were accessed at bridge crossings, from which we surveyed mainly upstream for an arbitrary distance (usually 45 minutes of walking). Typical distances were 100 - 400 meters.

Crayfish were collected using a number of different techniques, depending on the conditions of the waterway being sampled (e.g., substrate type, width/depth of water). Dip nets were used to collect crayfish from vegetation, debris jams, leaf/litter piles, etc. Often, when conditions allowed visual location of crayfish, we corralled individuals into dip nets. If not immediately visible, we overturned cobble and disturbed leaf litter to cause crayfish to become visible. This method worked well in most cases and provided us with the largest number of animals collected. We also collected crayfish in wide or deep (non-littoral) areas while seining or electrofishing. Both of these methods worked well but provided less animals per-unit effort than dip netting. Therefore, crayfish were collected secondarily using these methods when searching for listed fish species. Crayfish caught during electroshocking were not collected/recorded since they did not differ from those that were collected when dip netting. Crayfish (minnow) traps and pitfall traps were not used in this game land because of the high number of crayfish caught easily by the above methods. Collected specimens were preserved and stored in 70%-denatured ethanol.

Successful identification of many cambarid crayfishes usually requires collection of reproductive (Form I) males. Certain features of their gonopods – the first pair of abdominal appendages, or pleopods – can be important in their taxonomy. Form I males can be distinguished from Form II males by the advanced development of the terminal elements at the tips of their gonopods. In addition, Form I males have highly developed hooks on the ischia of certain walking legs



(pereiopods) that are used to hold the female during copulation. The size and shape of their chelae also may vary at this stage. Some common characteristics used in identification of non-Form I males are carapace length and depth/width ratio, areola width and length, presence and placement of spines, rostrum shape, color, and chela characteristics. Identification of crayfishes was accomplished through the use of taxonomic keys (Jezerinac et al. 1995, Cooper, *unpublished key*, and parts of various other keys) and a checklist (Hobbs Jr. 1989), by comparing individuals to reference collection specimens (North Carolina Wildlife Resources Commission, and North Carolina State Museum of Natural Sciences), and via personal communication with Dr. J.E. Cooper (NCSM, Curator of Crustaceans). As our understanding of crayfish taxonomy continues to improve, the identifications of the species we collected may change.

In addition to identifying individuals, we noted approximate abundances of each type of crayfish collected, and quantified average carapace lengths of those collected (from the tip of the rostrum to the posterior carapace edge). We also looked for evidence of recent reproduction and estimated habitat preferences of each species based on the areas from which they were collected. We recorded presence/absence data for each species encountered at each site visited to allow a crude estimate of the distribution of each species within the waterways associated with the game land. These data also will be added to a larger database describing state-wide distributions. Where possible, we recorded notes on ecological interactions (e.g., abundance of food, presence of competitors or predators, quality of habitat). For logistical and ethical reasons, we did not preserve every crayfish collected.

The nature and extent of this inventory of aquatic organisms did not allow us to perform rigorous quantitative sampling for crayfish. However, these data give us information on the distribution and relative abundance of the species encountered. In combination with previously collected data and known distributions, these data allow us to expand our knowledge of regional abundance and diversity. In so doing, we will be able to identify species that need some sort of protection and/or those that do not require protection as previously believed. We also will be able to identify waterways that have good crayfish populations but are in need of some measure of restoration in order to continue to provide adequate crayfish habitat. Alternatively, we may be able to identify waterways not currently containing crayfish that would provide suitable crayfish habitat if restored. In so doing, new habitat would be provided to other aquatic and riparian plants and animals. If crayfish are not collected from an area that should be suitable, we can begin to look for reasons precluding crayfish occurrence. Further, by providing collected specimens to the museum, we are contributing to our store of knowledge of North Carolina crayfishes.

## Results

Over 16 days from 18 June to 22 July 1998, 35 sites were inventoried and crayfish were collected or observed at all 35 sites (Figure 5 and Table 5). Four (and perhaps 5) species were collected during the survey period: *Cambarus* (*Puncticambarus*) sp. C (part of a species complex related to *C. (P.) acuminatus* (Faxon, 1884)), *Cambarus* (*Cambarus*) species undetermined, several juveniles that are possibly either *Cambarus* (*Lacunicambarus*) *diogenes* (Girard, 1852) or *Fallicambarus* (*Creaserinus*) *fodiens* (Cottle, 1863), an unidentified *Cambarus* juvenile, and *Procambarus* (*Ortmannicus*) *acutus* (Girard, 1852). The *C. (P.)* sp. C complex occurs across the



Coastal Plain, Piedmont, and Mountain physiographic regions of North Carolina and currently awaits further clarification (Cooper and Braswell 1995).

*Cambarus (P.)* sp. C. (no common name available) was most commonly found in pebble/gravel, and cobble substrates in riffle/run habitats. It also was found in root mats hanging over banks, and in leaf litter and woody debris. Juveniles were collected mostly from litter piles along stream edges or in backwater areas. This species complex was common in most waterways surveyed, becoming more abundant in streams with plenty of cover. Further, this species complex occurred in all of the waterways surveyed, indicating that it is widely distributed in the area. The presence of many juveniles of various sizes indicated that recent and fairly continuous reproduction was occurring. The collection of all life stages is not surprising, as this species complex is primarily a non-burrowing form that spends most of its life above ground (Hobbs 1989). Male carapace length ranged from 7.0 to 34.0 mm with a mean length of  $20.2 \pm 6.6$  mm ( $\pm$  standard deviation), and carapace length of females ranged from 6.0 to 36.5 mm with a mean length of  $18.7 \pm 6.5$  mm. Most males were Form II (non-reproductive), although 9 large Form I specimens were collected. One specimen, collected on 2 July (980702.2), was aberrant. This male had a short acumen, narrower areola, and lacked cervical and orbital spines.

*Procambarus (O.) acutus* (White River crayfish) was most commonly found in run and pool habitats where water was both deeper and slower. This type of habitat concurs with Hobbs' (1989) description as "sluggish to moderately flowing streams and most lentic situations." These types of habitat often had sand or silt substrate and ample leafy or woody debris. The animals also were found in root mats hanging over banks. Juveniles were collected mostly from litter piles along stream edges or in backwater areas, but always in shallower water. This species was much less common than *C.* sp. C, occurring at only 17 sites, but was relatively abundant in most waterways where it occurred, and rare in small streams where few lentic-like conditions existed. Further, this species occurred in about half of the waterways surveyed, indicating that it has a fairly good distribution in the area. Juveniles were present, but were not very abundant. Likely, this is because our survey occurred at a time during which this species had not recently reproduced. Had we visited during a different season, we may have witnessed more juveniles. However, because most males were Form I, this species was likely in the early stages of reproduction during our sampling period. Male carapace length ranged from 10.0 to 47.0 mm with a mean length of  $33.4 \pm 7.8$  mm, and carapace length of females ranged from 22.5 to 49.0 mm with a mean length of  $35.8 \pm 6.8$  mm.

In addition, we collected several juveniles of 2 (possibly 3) additional species. At 1 site (980715.2), 1 juvenile female *Cambarus (C.)* species undetermined (19 mm) was discovered in our collection. This animal may turn out to be *Cambarus (C.) bartonii* but more and larger specimens are needed to make this confirmation. We also found 2 tiny juvenile males and 1 tiny juvenile female in our sample from 1 site (980623.1:  $10.5 \pm 1.3$  mm) and 2 tiny juvenile females from a second site (980618.1:  $7.8 \pm 0.4$  mm) that are likely *Cambarus (L.) diogenes*, but may possibly be *Fallicambarus (C.) fodiens*. These individuals have a linear/obliterated areola, which limits their identification to 1 of these 2 species. Finally, we found 1 juvenile male *Cambarus* (15.5 mm) at a single site (980701.1) that does not belong to the *C. (P.)* sp. C complex, but we cannot determine the species. We discuss distribution implications in the discussion section.



## Discussion

The overall diversity of crayfish in this system was fair, but the abundances and distributions of two of the species encountered were high. Both *C. (P.)* sp. C. and *P. (O.) acutus* occurred together in many streams, although they were segregated by habitat in many cases. *C. (P.)* sp. C. generally occurred in faster-moving water, whereas *P. (O.) acutus* generally occurred in slower-moving water. Because the juveniles of *C. (C.)* species undetermined, *Cambarus* species undetermined, and *C. (L.) diogenes*/ *F. (C.) fodiens* were not discovered until they were being identified, we do not have any information about their habitats. The individual *C. (C.)* species undetermined may be restricted to intermittent and small streams, springs, and likely is a burrower, as are *C. (L.) diogenes* and *F. (C.) fodiens* (J.E. Cooper, pers. comm.).

Aspects of crayfish communities can tell us something about the system in which they occur. Although we did not directly test water quality, it was clear that the conditions in the Caswell Game Land were favorable to support crayfish (at least these species) in most of the streams sampled. Further, current reproduction was evident. However, the high siltation load in many of these streams should not have as great an impact on crayfish as it would on other biota (e.g., freshwater mussels). Potential food sources (e.g., allochthonous and autochthonous organic debris, aquatic insects) were abundant, although not much vegetation was present. Crayfish were occasionally seen away from cover, presumably foraging. Predation pressure on these crayfishes (especially juveniles) was likely substantial because the fish community in this system was healthy (see *Fish* section of this report). However, plenty of cover-providing habitat was available to crayfishes and likely lessened direct impact by predation. The potential for competition between crayfish species existed, but judging by the abundances of *C. (P.)* sp. C and *P. (O.) acutus*, did not appear to limit either of these populations. However, it is possible that they act as superior competitors to other species of crayfishes, keeping their populations below detection level.



We did not find any other species of crayfish historically found or thought to be in this river basin. However, the methods used in this study may have underestimated the presence and abundance of burrowing species such as *C. (L.) diogenes* and *F. (C.) fodiens*. We collected only 5 juveniles at 2 locations, which are likely 1 of these 2 species. There are currently no records of these 2 species in the Piedmont Plateau in the Roanoke River Basin, but they may occur as

far west as our survey area (J.E. Cooper, pers. comm.). The individual *C. (C.)* species undetermined may turn out to be *C. (C.) bartonii*, but this cannot be confirmed until more samples are collected and more individuals examined. The eastern extension of the range of this species is unknown. To our knowledge, *Orconectes (Crockerinus) virginianus* occurs no further west in the Roanoke River Basin than Granville County (J.E. Cooper, pers. comm.), so it is not surprising that we did not find any in this survey. The lack of *C. (Hiaticambarus) longulus* in our samples suggests that the distribution of this species apparently comes no further east than Rockingham County, as was previously thought (Cooper and Braswell 1995). Thus, this survey has helped to further clarify distribution boundaries of several species.

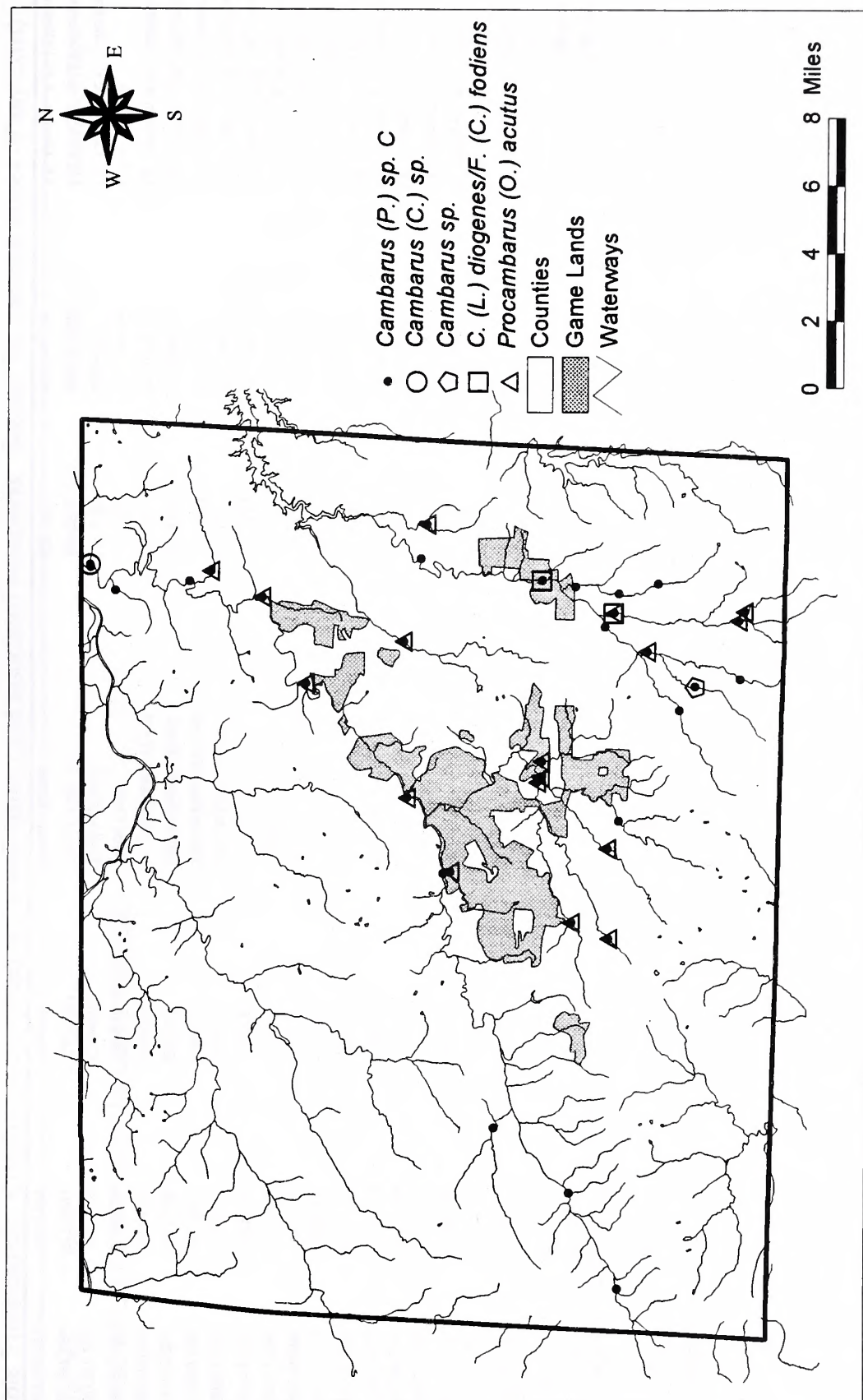


Figure 5. Map of sites indicating where each species of crayfish was collected in the Caswell Game Land aquatic inventory, Caswell County, North Carolina, 1998.



Table 5. Crayfish species found in Caswell Game Land associated waterways. See text for common names (if any exist).

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<u><i>Cambarus (Cambarus) sp.</i></u>						
980715.2bw	7/15/1998	Caswell	Trib to Country Line Creek	SR 1537	rare	J.E. Cooper
<u><i>Cambarus sp.</i></u>						
980701.1bw	7/1/1998	Caswell	Negro Creek	SR 1767	rare	J.E. Cooper
<u><i>Cambarus (Lacunicambarus) diogenes (possibly Fallicambarus (Creaserinus) fodiens)</i></u>						
980618.1bw	6/18/1998	Caswell	Hycro Creek	SR 1710	rare	A.H. Fullerton
980623.1bw	6/23/1998	Caswell	Lynch Creek	SR 1723	rare	J.E. Cooper
<u><i>Cambarus (Puncticambarus) sp. C</i></u>						
980618.1bw	6/18/1998	Caswell	Hycro Creek	SR 1710	abundant	J.E. Cooper, A.H. Fullerton
980623.1bw	6/23/1998	Caswell	Lynch Creek	SR 1723	common	J.E. Cooper, A.H. Fullerton
980624.1bw	6/24/1998	Caswell	S Country Line Creek	SR 1759	abundant	A.H. Fullerton
980624.2bw	6/24/1998	Caswell	Byrds Creek	SR 1751	abundant	J.E. Cooper, A.H. Fullerton
980624.3bw	6/24/1998	Caswell	Burkes Creek	SR 1732	abundant	J.E. Cooper, A.H. Fullerton
980624.4bw	6/24/1998	Caswell	Penson Creek	SR 1783	abundant	J.E. Cooper, A.H. Fullerton
980625.1bw	6/25/1998	Caswell	Country Line Creek	SR 1146	uncommon	J.E. Cooper, A.H. Fullerton
980625.2bw	6/25/1998	Caswell	Country Line Creek	SR 1129	uncommon	J.E. Cooper, A.H. Fullerton
980625.3bw	6/25/1998	Caswell	Country Line Creek	NC 62	uncommon	J.E. Cooper, A.H. Fullerton
980629.1bw	6/29/1998	Caswell	Panther Creek	SR 1723	common	J.E. Cooper, A.H. Fullerton
980629.2bw	6/29/1998	Caswell	N Hycro Creek	SR 1767	common	J.E. Cooper, A.H. Fullerton
980629.3bw	6/29/1998	Caswell	Trib to Hycro Creek (Negro Ck?)	SR 1765	uncommon	J.E. Cooper, A.H. Fullerton
980701.1bw	7/1/1998	Caswell	Negro Creek	SR 1767	common	J.E. Cooper, A.H. Fullerton
980701.2bw	7/1/1998	Caswell	Lynch Creek	SR 1771	uncommon	J.E. Cooper, A.H. Fullerton
980701.3bw	7/1/1998	Caswell	Trib to Lynch Creek	SR 1771	abundant	J.E. Cooper, A.H. Fullerton
980702.1bw	7/2/1998	Caswell	Trib to Panther Creek	SR 1774	abundant	J.E. Cooper, A.H. Fullerton
980702.2bw	7/2/1998	Caswell	Trib to Panther Creek	SR 1722	common	J.E. Cooper, A.H. Fullerton
980702.3bw	7/2/1998	Caswell	N Hycro Creek	NC 86, SR1786	common	J.E. Cooper, A.H. Fullerton
980707.1bw	7/7/1998	Caswell	Hycro Creek	US 158	uncommon	A.H. Fullerton
980707.2bw	7/7/1998	Caswell	Kilgore Creek	US 158	abundant	J.E. Cooper, A.H. Fullerton
980707.3bw	7/7/1998	Caswell	Reedy Fork	US 158	uncommon	J.E. Cooper, A.H. Fullerton
980708.1bw	7/8/1998	Caswell	Penson Creek	SR 1736	uncommon	J.E. Cooper, A.H. Fullerton

Table 5 (continued). Crayfish species found in Caswell Game Land associated waterways. See text for common names (if any exist).

Site No.	Date	County	Waterway	Road No.	Abundance	Identified By
<b><i>Cambarus (Puncticambarus) sp. C (continued)</i></b>						
980708.2bw	7/8/1998	Caswell	S Country Line Creek	SR 1736	uncommon	J.E. Cooper, A.H. Fullerton
980709.1bw	7/9/1998	Caswell	Hostettler Branch	NC 150	uncommon	J.E. Cooper, A.H. Fullerton
980709.2bw	7/9/1998	Caswell	Trib to S Country Line Creek	SR 1730	uncommon	J.E. Cooper, A.H. Fullerton
980709.3bw	7/9/1998	Caswell	Benay Creek	NC 62	common	J.E. Cooper, A.H. Fullerton
980714.1bw	7/14/1998	Caswell	Country Line Creek	SR 1554	uncommon	J.E. Cooper, A.H. Fullerton
980714.2bw	7/14/1998	Caswell	Kilgore Creek	SR 1557	common	J.E. Cooper, A.H. Fullerton
980714.3bw	7/14/1998	Caswell	Trib to Country Line Creek	SR 1538	abundant	A.H. Fullerton
980715.1bw	7/15/1998	Caswell	Country Line Creek	SR 1780	uncommon	J.E. Cooper, A.H. Fullerton
980715.2bw	7/15/1998	Caswell	Trib to Country Line Creek	SR 1537	uncommon	J.E. Cooper, A.H. Fullerton
980715.3bw	7/15/1998	Caswell	Country Line Creek	NC 57	uncommon	J.E. Cooper, A.H. Fullerton
980715.4bw	7/15/1998	Caswell	Country Line Creek	SR 1565	uncommon	J.E. Cooper, A.H. Fullerton
980716.1bw	7/16/1998	Caswell	Country Line Creek	SR 1597	uncommon	J.E. Cooper, A.H. Fullerton
980716.2bw	7/16/1998	Caswell	Trib to Hyco Creek	SR 1767	uncommon	J.E. Cooper, A.H. Fullerton
<b><i>Procambarus (Ortmannicus) acutus</i></b>						
980623.1bw	6/23/1998	Caswell	Lynch Creek	SR 1723	rare	J.E. Cooper, A.H. Fullerton
980624.2bw	6/24/1998	Caswell	Byrds Creek	SR 1751	rare	J.E. Cooper, A.H. Fullerton
980624.3bw	6/24/1998	Caswell	Burkes Creek	SR 1732	abundant	J.E. Cooper, A.H. Fullerton
980624.4bw	6/24/1998	Caswell	Penson Creek	SR 1783	abundant	J.E. Cooper, A.H. Fullerton
980629.3bw	6/29/1998	Caswell	Trib to Hyco Creek (Negro Ck?)	SR 1765	rare	J.E. Cooper, A.H. Fullerton
980701.2bw	7/1/1998	Caswell	Lynch Creek	SR 1771	rare	J.E. Cooper, A.H. Fullerton
980701.3bw	7/1/1998	Caswell	Trib to Lynch Creek	SR 1771	common	J.E. Cooper, A.H. Fullerton
980707.2bw	7/7/1998	Caswell	Kilgore Creek	US 158	rare	J.E. Cooper, A.H. Fullerton
980707.3bw	7/7/1998	Caswell	Reedy Fork	US 158	uncommon	J.E. Cooper, A.H. Fullerton
980708.1bw	7/8/1998	Caswell	Penson Creek	SR 1736	uncommon	J.E. Cooper, A.H. Fullerton
980708.2bw	7/8/1998	Caswell	S Country Line Creek	SR 1736	rare	J.E. Cooper, A.H. Fullerton
980709.2bw	7/9/1998	Caswell	Trib to S Country Line Creek	SR 1730	rare	J.E. Cooper, A.H. Fullerton
980709.3bw	7/9/1998	Caswell	Benay Creek	NC 62	common	J.E. Cooper, A.H. Fullerton
980714.2bw	7/14/1998	Caswell	Kilgore Creek	SR 1557	rare	J.E. Cooper, A.H. Fullerton
980715.4bw	7/15/1998	Caswell	Country Line Creek	SR 1565	rare	J.E. Cooper, A.H. Fullerton
980716.1bw	7/16/1998	Caswell	Country Line Creek	SR 1597	rare	J.E. Cooper, A.H. Fullerton
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1767	uncommon	J.E. Cooper, A.H. Fullerton



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# **FRESHWATER FISHES**

Brian T. Watson, Nongame Wildlife Biologist  
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Division of Wildlife Management  
NC Wildlife Resources Commission

## **Introduction**

Fishes are the most numerous and diverse of the major vertebrate groups. Their various morphological, behavioral, reproductive, and physiological adaptations have allowed them to dominate the waters of the world. Fishes can be found in a broad array of habitats, including vernal pools, mountain streams, and the ocean floor. Their dominance is reflected in the number of living species: over 24,600 species have been described (Moyle and Cech 1996) and it is believed that this number may increase to approximately 28,500 (Nelson 1994). The North American continent harbors approximately 1,100 species of freshwater fish (Burr and Mayden 1992), with 790 (75%) species occurring in the United States (Page and Burr 1991). More than 225 species can be found in North Carolina, with nearly 50 of these documented in Caswell County (Menhinick 1991).

While most of the attention from the public and fisheries biologists is directed towards the game fishes, these species make up only about 5% of the freshwater fish fauna in the United States. The remaining 95% are little known, but charismatic, nongame species, such as darters and minnows. Nongame fishes play a vital role in the balance of aquatic ecosystems. Their diets are diverse, and, in turn, they serve as dietary components for sport fishes, water birds, and other wildlife. They also are important indicators of water quality and can signal when aquatic ecosystems are being negatively impacted. Game fishes also are important components of aquatic ecosystems and provide a source of recreation and employment for many people. Unfortunately, in 1989, the American Fisheries Society regarded 364 North American freshwater fish species as endangered, threatened, or special concern, an increase of 45% in just 10 years (Williams et al. 1989). This number represents approximately one-third of the North American native freshwater fish fauna. In North Carolina, approximately 25% of the freshwater fishes are state listed. Some of the reasons for this decline include habitat alteration and loss, chemical pollution, exploitation, and introduction of exotic species. Given this information, it is essential that we better understand the taxonomy, distribution, and conservation needs of the various taxa. Therefore, a freshwater fish inventory of the waterways associated with the state-owned Caswell Game Land was initiated to ascertain some of this needed information.

## **Methods**

The freshwater fish survey of Caswell Game Land was conducted during the summer of 1998. The game land, located in Caswell County, North Carolina, encompasses 16,614 acres. Refer to the Report Introduction for details on history of land use, drainage basin and waterway descriptions, and a map of all surveyed sites. Waterways were accessed at bridge crossings, from which we surveyed mainly upstream for an arbitrary distance (usually 45 minutes of walking). Typical distances were 100 - 400 meters.



**Subject:** Re: Fish Specimen Verification from NCWRC's 1998 Caswell Gameland Inventory  
**From:** Wayne Starnes <Wayne.Starnes@ncmail.net>  
**Date:** Wed, 14 Apr 2004 16:50:04 -0400  
**To:** Bryn Tracy <bryn.tracy@ncmail.net>  
**CC:** "Gabriela.Hogue" <Gabriela.Hogue@ncmail.net>

Bryn--In checking the collection/data base, I see no indication any of these specs (some of these dubious records to be sure) were vouchered here. That's really too bad. I'm not sure what the source of the T.L. Fulbright determinations could be unless it's something Bryan brought by here for verification and then took away. I don't recall seeing any of this stuff, though I did look at a lot of stuff from some of his other surveys. The Ambloplites would have been especially nice, seeing as how there (oddly) are no records of Ambloplites of any sort from NC portion of the Dan as far as I know. If this and the catfishes, etc., were field releases, then I'd have to say the records are quite probably worthless. I hope he's wrong about the Flathead. Who knows on the melas; they could pop up anywhere based on sporadic occurrences in NC (introductions). -W

Bryn Tracy wrote:

It is raining, so I have to find something to keep myself busy. Because we may sample the Roanoke River basin this year, if it stops raining, I thought I would review what Gabriella's old cohorts had found. The document this information comes from is: Watson, B. T. and A. H. Fullerton 1999. Caswell gameland aquatic inventory. NCWRC. Raleigh, NC. Here are my questions:

1. *Ambloplites rupestris*, Hyco Creek, US 158, Caswell County, NC, July 22, 1998, identified by B. T. Watson. Question -- was specimen vouchered with the Museum and how did he know it was not *A. cavifrons*?
2. *Ameiurus melas*, Country Line Creek, SR 1554, Caswell County, NC, July 20, 1998, identified by B. T. Watson. Question -- was specimen vouchered with the Museum and how did he know it was not *A. nebulosus*?
3. *Etheostoma podostemone*, Country Line Creek, SR 1780, Caswell County, NC, July 20, 1998, identified by T. L. Fulbright. Question -- was specimen vouchered with the Museum and how did she know it was not *E. nigrum*?
4. *Notropis scepticus*, Country Line Creek, SR 1780, Caswell County, NC, July 20, 1998, identified by T. L. Fulbright. Question -- was specimen vouchered with the Museum and could she have confused it with *Luxilus albeolus* or *L. cerasinus*? *N. scepticus* has never been found in the Roanoke drainage.
5. *Pylodictis olivaris*, Country Line Creek, NC 57, Caswell County, NC, July 20, 1998, identified by B. T. Watson. Question -- was specimen vouchered with the Museum?

Thanks for your help. Wayne -- I hope you had a good time at Ocracoke.



--

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Wayne C. Starnes, Ph.D., Research Curator of Fishes >^^> >^^>  
North Carolina State Museum of Natural Sciences  
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Museum Web Site: <http://www.naturalsciences.org>

My lab & postal/shipping address location:  
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Research Laboratory  
4301 Reedy Creek Rd., Raleigh, NC 27607 USA

Freshwater fishes were collected using a variety of techniques depending on the conditions of the site being surveyed (e.g., water depth, visibility, substrata types). The most common method used was backpack electroshocking. This method was chosen because it is more comprehensive and efficient than other methods used to collect fishes in streams. Other techniques incorporated into the survey included the use of a 6' x 10' seine and dip nets. Most fishes collected were identified to species and released unharmed. However, it was necessary to perform some identifications in the laboratory. This was carried out by fixing the fish in 10% formalin and preserving them in 70%-denatured alcohol. Once the fishes were preserved, they were identified with the use of a compound microscope (Nikon). Fishes were identified according to Menhinick (1991), Page and Burr (1991), Rhode et al. (1994), and Jenkins and Burkhead (1994). Dr. Wayne C. Starnes and others from the NC State Museum of Natural Sciences verified some identifications. Besides presence-absence data, relative abundance and recent reproduction information were noted for each species to determine population health.

## Results

Over 16 days from 18 June to 22 July 1998, 35 sites were inventoried and fish were collected or observed at all 35 sites (Figure 6). Forty-two species representing ten families were documented during the survey of Caswell County (Tables 6 and 7). Of the nearly 50 species that have been documented in Caswell County, we confirmed the presence of 35 of these species. Limitations as to our access of all available habitats and sampling range within the county were the most likely reasons for the absence of particular species. However, we did document the presence of 8 species that have not been shown to exist in Caswell County: *Pyloodictus olivaris*, *Ameiurus melas*, *Gambusia holbrooki*, *Ambloplites rupestris*, *Hybognathus regius*, *Etheostoma podostemone*, *E. vitreum* and *Percina roanoka*. Overall, abundance, distribution, and recent reproduction were fair to high for most species encountered.

## Discussion

The waterways associated with Caswell Game Land contain a high diversity and widespread distributions of fish species. While some of the fish species were collected at isolated locations (e.g., *Aphredoderus sayanus* and *Hypentelium roanokense*), a majority occurred over a broad area. The species abundance tended to vary between sites, with *Nocomis leptocephalus*, *Semotilus atromaculatus*, *Clinostomus funduloides*, *Notropis* spp, and *Lepomis* spp. comprising the majority of the biomass at most of the sites. The relatively low abundance of a majority of the species was probably due to the lack of habitat diversity. The substrata at most sites was comprised of sand and clay banks, with low amounts of woody debris, and a run-slack flow regime. The lack of riffles, pools, high flow near the edge, and debris limited the success of species such as *Hypentelium* spp., *Moxostoma* spp., and *Etheostoma* spp.

Eight species were documented during this survey that are not shown to extend into Caswell County (Menhinick 1991). These species included *Pyloodictus olivaris*, *Ameiurus melas*, *Gambusia holbrooki*, *Ambloplites rupestris*, *Hybognathus regius*, *Etheostoma podostemone*, *E. vitreum*, and *Percina roanoka*. Given the close proximity to which the *Pyloodictus olivaris* was seen from the confluence of Country Line Creek and the Dan River, it is not surprising that this species occurs in the county since local fishermen claim to have caught this species from the Dan River. The single individual of *A. rupestris* collected in Hyco Creek most likely came from



Hyc0 Lake. The introduction of sport fish such as sunfish and bass into lakes is why it is likely the specimen came from Hyc0 Lake. Accidental or intentional introductions of species, such as *A. rupestris* and *P. olivaris*, are of concern. Non-native species may compete with native species, and they may cause imbalances in aquatic communities. Additionally, if closely related species, such as *A. cavifrons*, were present, hybridization with *A. rupestris* could degrade the genetic integrity of the local *A. cavifrons* population. The other newly documented species have ranges that border Caswell County, so a lack of surveys coupled with their isolation and rarity may be the reason for no previous records.

Significant species found during the survey included *Etheostoma podostemone* (riverweed darter) and *Hypentelium roanokense* (Roanoke hogsucker). A single specimen of *E. podostemone* was collected from 1 site on Country Line Creek. This individual was collected from an area with run-like flow, predominantly sand substrata, and minimal debris. Currently, the riverweed darter is listed as a species of special concern within North Carolina. Likewise, a few Roanoke hogsuckers were located at 2 sites in the Country Line Creek Subbasin. These individuals were collected in deeper areas containing rock outcroppings and boulders along the edge of the channel. No recent reproduction was noticed, as most individuals collected were larger in size. The Roanoke hogsucker is not listed at this time, but it is considered to be a rare species in North Carolina since it is endemic to the Roanoke River Basin. Given the rarity in which these 2 species are found in the Roanoke River Basin in North Carolina, additional surveys should be conducted to determine the extent of the species' range and the health of any populations.

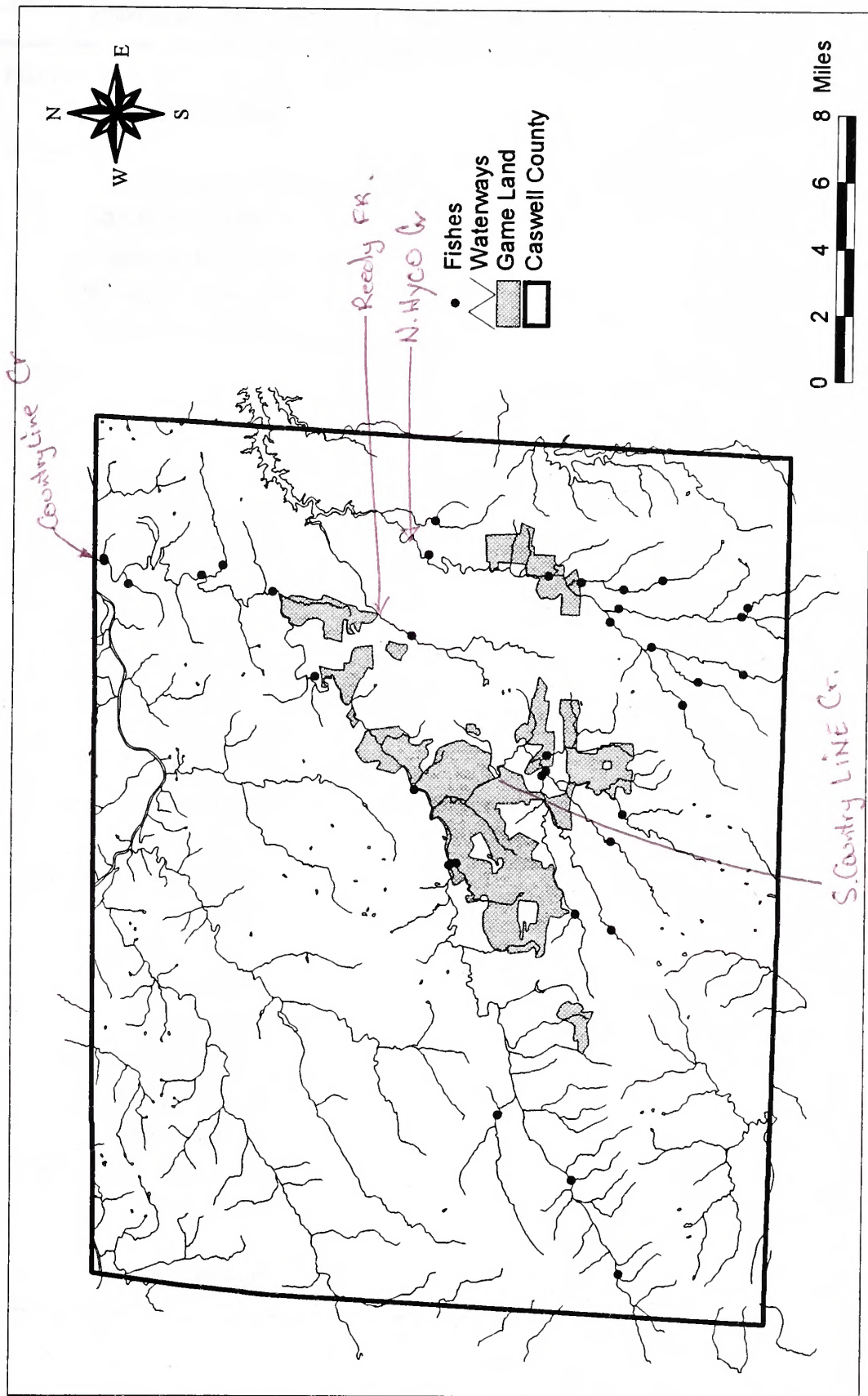


Figure 6. Map of sites indicating where fishes were collected in the Caswell Game Land aquatic inventory, Caswell County, North Carolina, 1998.



Table 6. Freshwater fish species found in Caswell Game Land associated waterways.

Aphredoderidae

*Aphredoderus sayanus*

Pirate perch

Catostomidae

*Catostomus commersoni*

White sucker

*Erimyzon oblongus*

Creek chubsucker

*Hypentelium nigricans*

Northern hogsucker

*Hypentelium roanokense*

Roanoke hogsucker

*Moxostoma erythrurum*

Golden redhorse

*Moxostoma collapsum*

V-lip redhorse

Centrarchidae

*Ambloplites rupestris* - new record

Rock bass

*Lepomis auritus*

Redbreast sunfish

*Lepomis cyanellus*

Green sunfish

*Lepomis gibbosus*

Pumpkinseed sunfish

*Lepomis macrochirus*

Bluegill sunfish

*Micropterus salmoides*

Largemouth bass

*Pomoxis nigromaculatus*

Black crappie

Clupeidae

*Dorosoma cepedianum*

Gizzard shad

Cyprinidae

*Clinostomus funduloides*

Rosyside dace

*Cyprinella analostana*

Satinfin shiner

*Hybognathus regius*

Eastern silvery minnow

*Luxilus albeolus*

White shiner

*Luxilus cerasinus*

Crescent shiner

*Lythrurus ardens*

Rosefin shiner

*Nocomis leptcephalus*

Bluehead chub

*Notropis amoenus*

Comely shiner

*Notropis procne*

Swallowtail shiner

*Notropis scepticus*

Sandbar shiner

*Phoxinus oreas*

Mountain redbelly dace

*Semotilus atromaculatus*

Creek chub

Esocidae

*Esox americanus*

Redfin pickerel

Table 6 (cont.). Freshwater fish species found in Caswell Game Land associated waterways.

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Fundulidae

*Fundulus rathbuni*

Speckled killifish

Ictaluridae

*Ameiurus melas* - new record

Black bullhead

*Ameiurus natalis*

Yellow bullhead

*Ictalurus punctatus*

Channel catfish

*Noturus insignis*

Margined madtom

*Pylodictus olivaris* - new record

Flathead catfish

Percidae

*Etheostoma flabellare*

Fantail darter

*Etheostoma nigrum*

Johnny darter

*Etheostoma podostemone* - new record

Riverweed darter

*Etheostoma vitreum*

Glassy darter

*Perca flavescens*

Yellow perch

*Percina peltata* new record

Chainback

Shield darter

*Percina roanoka*

Roanoke darter

Poeciliidae

*Gambusia holbrooki* - new record

Eastern mosquitofish

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Table 7. Freshwater fish species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<u><i>Ambloplites rupestris</i></u>						
980722.8bw	7/22/1998	Caswell	Hyc Creek	US 158	rare	B.T. Watson
<u><i>Ameiurus melas</i></u>						
980720.5bw	7/20/1998	Caswell	Country Line Creek	SR 1554	rare	B.T. Watson
<u><i>Ameiurus natalis</i></u>						
980707.2bw	7/7/1998	Caswell	Kilgore Creek	US 158	rare	B.T. Watson
980708.3bw	7/8/1998	Caswell	South Country Line Creek	SR 1759	rare	B.T. Watson
980715.4bw	7/15/1998	Caswell	Country Line Creek	SR 1565	rare	B.T. Watson
980716.1bw	7/16/1998	Caswell	Country Line Creek	SR 1597	uncommon	B.T. Watson, G.B. Mottesi
980720.5bw	7/20/1998	Caswell	Country Line Creek	SR 1554	rare	B.T. Watson
980721.7bw	7/21/1998	Caswell	Negro Creek	SR 1765	rare	B.T. Watson
980722.7bw	7/22/1998	Caswell	Hyc Creek	US 158	rare	B.T. Watson
980722.8bw	7/22/1998	Caswell	Kilgore Creek	US 158	uncommon	B.T. Watson
<u><i>Aphredoderus sayanus</i></u>						
980721.7bw	7/21/1998	Caswell	Negro Creek	SR 1765	rare	B.T. Watson
<u><i>Catostomus commersoni</i></u>						
980701.3bw	7/1/1998	Caswell	Trib to Lynch Creek	SR 1771	rare	B.T. Watson
980702.2bw	7/2/1998	Caswell	Trib to Panther Creek	SR 1722	rare	B.T. Watson
980707.2bw	7/7/1998	Caswell	Kilgore Creek	US 158	uncommon	B.T. Watson, G.B. Mottesi
980715.4bw	7/15/1998	Caswell	Country Line Creek	SR 1565	uncommon	B.T. Watson
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1780	uncommon	B.T. Watson
980720.3bw	7/20/1998	Caswell	Country Line Creek	NC 57	present	B.T. Watson
980721.1bw	7/21/1998	Caswell	Byrds Creek	SR 1751	patchy common	B.T. Watson
980721.1bw	7/21/1998	Caswell	Kilgore Creek	SR 1557	uncommon	B.T. Watson
980721.4bw	7/21/1998	Caswell	Lynch Creek	SR 1723	uncommon	B.T. Watson
980722.3bw	7/22/1998	Caswell	Penson Creek	SR 1783	uncommon	B.T. Watson
980722.8bw	7/22/1998	Caswell	Kilgore Creek	US 158	uncommon	B.T. Watson

Table 7 (cont.). Freshwater fish species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<i>Clinostomus funduloides</i>						
980629.1bw	6/29/1998	Caswell	Panther Creek	SR 1723	common	B.T. Watson
980701.1bw	7/1/1998	Caswell	Negro Creek	SR 1767	common	B.T. Watson
980701.3bw	7/1/1998	Caswell	Trib to Lynch Creek	SR 1771	common	B.T. Watson
980702.1bw	7/2/1998	Caswell	Trib to Panther Creek	SR 1774/1775	common	B.T. Watson
980707.2bw	7/7/1998	Caswell	Kilgore Creek	US 158	common	B.T. Watson
980709.2bw	7/9/1998	Caswell	Trib to S Country Line Creek	SR 1730	common	B.T. Watson
980709.3bw	7/9/1998	Caswell	Benay Creek	NC 62	common	B.T. Watson
980714.1bw	7/14/1998	Caswell	Country Line Creek	SR 1554	common	B.T. Watson
980714.2bw	7/14/1998	Caswell	Kilgore Creek	SR 1557	common	B.T. Watson
980714.3bw	7/14/1998	Caswell	Trib to Country Line Creek	SR 1538	common	B.T. Watson
980715.2bw	7/15/1998	Caswell	Trib to Country Line Creek	SR 1540	common	B.T. Watson
980716.2bw	7/16/1998	Caswell	Trib to Hyco Creek	SR 1767	common	B.T. Watson
980720.2bw	7/20/1998	Caswell	Trib to Country Line Creek	SR 1537?	common	B.T. Watson
980720.4bw	7/20/1998	Caswell	Trib to Country Line Creek	SR 1538	uncommon	B.T. Watson
980721.1bw	7/21/1998	Caswell	Byrds Creek	SR 1751	common	B.T. Watson
980721.1bw	7/21/1998	Caswell	Kilgore Creek	SR 1557	common	B.T. Watson
980721.3bw	7/21/1998	Caswell	Panther Creek	SR 1723	common	B.T. Watson
980721.4bw	7/21/1998	Caswell	Lynch Creek	SR 1723	common	B.T. Watson
980721.6bw	7/21/1998	Caswell	Lynch Creek	SR 1771	common	B.T. Watson
980721.7bw	7/21/1998	Caswell	Negro Creek	SR 1765	common	B.T. Watson
980721.8bw	7/21/1998	Caswell	Trib to Negro Creek	SR 1767	uncommon	B.T. Watson
980722.1bw	7/22/1998	Caswell	Hostettler Branch	NC 150	common	B.T. Watson
980722.3bw	7/22/1998	Caswell	Penson Creek	SR 1783	common	B.T. Watson
980722.4bw	7/22/1998	Caswell	Burkes Creek	SR 1732	common	B.T. Watson
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	common	B.T. Watson
980722.8bw	7/22/1998	Caswell	Kilgore Creek	US 158	common	B.T. Watson
<i>Cyprinella analostana</i>						
980618.1bw	6/18/1998	Caswell	Hyco Creek	SR 1710	common	W.C. Starnes, G.B. Mottesi
980625.2bw	6/25/1998	Caswell	Country Line Creek	SR 1129	common	B.T. Watson
980625.3bw	6/25/1998	Caswell	Country Line Creek	NC 62	common	B.T. Watson
980707.1bw	7/7/1998	Caswell	Hyco Creek	US 158	uncommon	B.T. Watson



Table 7 (cont.). Freshwater fish species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<b><u>Cyprinella analostana</u></b>						
980714.1bw	7/14/1998	Caswell	Country Line Creek	SR 1554	uncommon	B.T. Watson
980715.3bw	7/15/1998	Caswell	Country Line Creek	NC 57	uncommon	B.T. Watson, G.B. Mottesi
980715.4bw	7/15/1998	Caswell	Country Line Creek	SR 1565	common	B.T. Watson
980716.1bw	7/16/1998	Caswell	Country Line Creek	SR 1597	common	B.T. Watson
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1780	common	B.T. Watson, T.L. Fullbright
980720.3bw	7/20/1998	Caswell	Country Line Creek	NC 57	common	B.T. Watson
980721.2bw	7/21/1998	Caswell	Hycro Creek	SR 1710	common	B.T. Watson
980721.4bw	7/21/1998	Caswell	Lynch Creek	SR 1723	common	B.T. Watson
980721.7bw	7/21/1998	Caswell	Negro Creek	SR 1765	common	B.T. Watson, M.E. Raney
980721.9bw	7/21/1998	Caswell	N Hycro Creek	SR 1767	uncommon	B.T. Watson
980722.2bw	7/22/1998	Caswell	Country Line Creek	SR 1129	common	B.T. Watson
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	common	B.T. Watson
980722.6bw	7/22/1998	Caswell	Reedy Fork	US 158	uncommon	B.T. Watson
980722.7bw	7/22/1998	Caswell	Hycro Creek	US 158	common	B.T. Watson
<b><u>Dorosoma cepedianum</u></b>						
980715.3bw	7/15/1998	Caswell	Country Line Creek	NC 57	rare	B.T. Watson
<b><u>Erimyzon oblongus</u></b>						
980618.1bw	6/18/1998	Caswell	Hycro Creek	SR 1710	rare	B.T. Watson
980707.3bw	7/7/1998	Caswell	Reedy Fork	US 158	uncommon	B.T. Watson
980708.3bw	7/8/1998	Caswell	South Country Line Creek	SR 1759	rare	B.T. Watson
980720.5bw	7/20/1998	Caswell	Country Line Creek	SR 1554	rare	B.T. Watson, G.B. Mottesi
980721.1bw	7/21/1998	Caswell	Byrds Creek	SR 1751	uncommon	B.T. Watson
980721.5bw	7/21/1998	Caswell	Trib to Panther Creek	SR 1774	uncommon	B.T. Watson
980721.7bw	7/21/1998	Caswell	Negro Creek	SR 1765	uncommon	B.T. Watson, M.E. Raney
980721.9bw	7/21/1998	Caswell	N Hycro Creek	SR 1767	common	B.T. Watson, G.B. Mottesi
980722.3bw	7/22/1998	Caswell	Penson Creek	SR 1783	uncommon	B.T. Watson, G.B. Mottesi
980722.4bw	7/22/1998	Caswell	Burkes Creek	SR 1732	common	B.T. Watson
980722.8bw	7/22/1998	Caswell	Kilgore Creek	US 158	common	B.T. Watson
<b><u>Esox americanus</u></b>						
980708.1bw	7/8/1998	Caswell	Penson Creek	SR 1736	rare	B.T. Watson
980708.2bw	7/8/1998	Caswell	S Country Line Creek	SR 1736	rare	B.T. Watson
980715.3bw	7/15/1998	Caswell	Country Line Creek	NC 57	rare	B.T. Watson

Table 7 (cont.). Freshwater fish species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<i>Esox americanus</i>						
980720.3bw	7/20/1998	Caswell	Country Line Creek	NC 57	uncommon	B.T. Watson
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	uncommon	B.T. Watson
<i>Etheostoma flabellare</i>						
980625.1bw	6/25/1998	Caswell	Country Line Creek	SR 1146	uncommon	B.T. Watson
980629.1bw	6/29/1998	Caswell	Panther Creek	SR 1723	rare	B.T. Watson
980701.1bw	7/1/1998	Caswell	Negro Creek	SR 1767	rare	B.T. Watson
980701.3bw	7/1/1998	Caswell	Trib to Lynch Creek	SR 1771	rare	B.T. Watson
980702.1bw	7/2/1998	Caswell	Trib to Panther Creek	SR 1774/1775	rare	B.T. Watson
980702.2bw	7/2/1998	Caswell	Trib to Panther Creek	SR 1722	rare	B.T. Watson
980707.3bw	7/7/1998	Caswell	Reedy Fork	US 158	rare	B.T. Watson
980708.1bw	7/8/1998	Caswell	Penson Creek	SR 1736	rare	B.T. Watson
980708.2bw	7/8/1998	Caswell	S Country Line Creek	SR 1736	rare	B.T. Watson
980708.3bw	7/8/1998	Caswell	South Country Line Creek	SR 1759	rare	B.T. Watson
980709.2bw	7/9/1998	Caswell	Trib to S Country Line Creek	SR 1730	rare	B.T. Watson
980709.3bw	7/9/1998	Caswell	Benay Creek	NC 62	rare	B.T. Watson
980714.1bw	7/14/1998	Caswell	Country Line Creek	SR 1554	rare	B.T. Watson
980714.2bw	7/14/1998	Caswell	Kilgore Creek	SR 1557	rare	B.T. Watson
980714.3bw	7/14/1998	Caswell	Trib to Country Line Creek	SR 1538	rare	B.T. Watson
980715.2bw	7/15/1998	Caswell	Trib to Country Line Creek	SR 1540	rare	B.T. Watson
980715.3bw	7/15/1998	Caswell	Country Line Creek	NC 57	rare	B.T. Watson
980716.1bw	7/16/1998	Caswell	Country Line Creek	SR 1597	uncommon	B.T. Watson
980716.2bw	7/16/1998	Caswell	Trib to Hyco Creek	SR 1767	rare	B.T. Watson
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1780	rare	B.T. Watson
980720.2bw	7/20/1998	Caswell	Trib to Country Line Creek	SR 1537?	rare	B.T. Watson
980720.4bw	7/20/1998	Caswell	Trib to Country Line Creek	SR 1538	rare	B.T. Watson
980720.5bw	7/20/1998	Caswell	Country Line Creek	SR 1554	uncommon	B.T. Watson
980721.10bw	7/21/1998	Caswell	S Country Line Creek	SR 1759	rare	B.T. Watson
980721.11bw	7/21/1998	Caswell	Byrds Creek	SR 1751	uncommon	B.T. Watson
980721.1bw	7/21/1998	Caswell	Kilgore Creek	SR 1557	rare	B.T. Watson
980721.2bw	7/21/1998	Caswell	Hyco Creek	SR 1710	rare	B.T. Watson
980721.3bw	7/21/1998	Caswell	Panther Creek	SR 1723	rare	B.T. Watson
980721.4bw	7/21/1998	Caswell	Lynch Creek	SR 1723	rare	B.T. Watson
980721.5bw	7/21/1998	Caswell	Trib to Panther Creek	SR 1774	rare	B.T. Watson
980721.6bw	7/21/1998	Caswell	Lynch Creek	SR 1771	rare	B.T. Watson



Table 7 (cont.). Freshwater fish species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<b><u>Etheostoma flabellare</u></b>						
980721.7bw	7/21/1998	Caswell	Negro Creek	SR 1765	rare	B.T. Watson
980721.8bw	7/21/1998	Caswell	Trib to Negro Creek	SR 1767	rare	B.T. Watson
980721.9bw	7/21/1998	Caswell	N Hyco Creek	SR 1767	uncommon	B.T. Watson
980722.1bw	7/22/1998	Caswell	Hostettler Branch	NC 150	uncommon	B.T. Watson
980722.2bw	7/22/1998	Caswell	Country Line Creek	SR 1129	rare	B.T. Watson
980722.3bw	7/22/1998	Caswell	Penson Creek	SR 1783	uncommon	B.T. Watson
980722.4bw	7/22/1998	Caswell	Burkes Creek	SR 1732	rare	B.T. Watson
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	uncommon	B.T. Watson
980722.8bw	7/22/1998	Caswell	Kilgore Creek	US 158	rare	B.T. Watson
<b><u>Etheostoma nigrum</u></b>						
980629.1bw	6/29/1998	Caswell	Panther Creek	SR 1723	rare	B.T. Watson
980701.3bw	7/1/1998	Caswell	Trib to Lynch Creek	SR 1771	rare	B.T. Watson
980707.1bw	7/7/1998	Caswell	Hyco Creek	US 158	rare	B.T. Watson
980707.2bw	7/7/1998	Caswell	Kilgore Creek	US 158	rare	B.T. Watson
980708.1bw	7/8/1998	Caswell	Penson Creek	SR 1736	rare	B.T. Watson
980709.2bw	7/9/1998	Caswell	Trib to S Country Line Creek	SR 1730	rare	B.T. Watson
980715.2bw	7/15/1998	Caswell	Trib to Country Line Creek	SR 1540	rare	B.T. Watson
980715.3bw	7/15/1998	Caswell	Country Line Creek	NC 57	rare	B.T. Watson
980716.1bw	7/16/1998	Caswell	Country Line Creek	SR 1597	common	G.B. Mottes
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1780	uncommon	B.T. Watson, G.B. Mottes
980720.3bw	7/20/1998	Caswell	Country Line Creek	NC 57	uncommon	B.T. Watson, T.L. Fullbright
980720.5bw	7/20/1998	Caswell	Country Line Creek	SR 1554	uncommon	B.T. Watson
980721.10bw	7/21/1998	Caswell	S Country Line Creek	SR 1759	uncommon	B.T. Watson
980721.11bw	7/21/1998	Caswell	Byrds Creek	SR 1751	uncommon	B.T. Watson
980721.2bw	7/21/1998	Caswell	Hyco Creek	SR 1710	uncommon	B.T. Watson
980721.7bw	7/21/1998	Caswell	Negro Creek	SR 1765	uncommon	B.T. Watson
980722.2bw	7/22/1998	Caswell	Country Line Creek	SR 1129	uncommon	B.T. Watson
980722.3bw	7/22/1998	Caswell	Penson Creek	SR 1783	uncommon	B.T. Watson
980722.4bw	7/22/1998	Caswell	Burkes Creek	SR 1732	uncommon	B.T. Watson
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	uncommon	B.T. Watson
980722.7bw	7/22/1998	Caswell	Hyco Creek	US 158	uncommon	B.T. Watson
980722.8bw	7/22/1998	Caswell	Kilgore Creek	US 158	uncommon	B.T. Watson
<b><u>Etheostoma podostemone</u></b>						
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1780	rare	T.L. Fullbright

Table 7 (cont.). Freshwater fish species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<i>Etheostoma vitreum</i>						
980715.3bw	7/15/1998	Caswell	Country Line Creek	NC 57	rare	G.B. Mottesi, B.T. Watson
<i>Fundulus rathbuni</i>						
980618.1bw	6/18/1998	Caswell	Hycro Creek	SR 1710	common	B.T. Watson
980625.1bw	6/25/1998	Caswell	Country Line Creek	SR 1146	common	B.T. Watson
980629.1bw	6/29/1998	Caswell	Panther Creek	SR 1723	common	B.T. Watson
980701.1bw	7/1/1998	Caswell	Negro Creek	SR 1767	common	B.T. Watson
980701.3bw	7/1/1998	Caswell	Trib to Lynch Creek	SR 1771	common	B.T. Watson
980702.3bw	7/2/1998	Caswell	N Hycro Creek	NC 86, SR 1786	common	B.T. Watson
980707.1bw	7/7/1998	Caswell	Hycro Creek	US 158	common	B.T. Watson
980708.2bw	7/8/1998	Caswell	S Country Line Creek	SR 1736	common	B.T. Watson
980709.2bw	7/9/1998	Caswell	Trib to S Country Line Creek	SR 1730	uncommon	B.T. Watson
980714.1bw	7/14/1998	Caswell	Country Line Creek	SR 1554	common	B.T. Watson
980715.2bw	7/15/1998	Caswell	Trib to Country Line Creek	SR 1540	common	B.T. Watson
980715.4bw	7/15/1998	Caswell	Country Line Creek	SR 1565	common	B.T. Watson
980716.1bw	7/16/1998	Caswell	Country Line Creek	SR 1597	common	B.T. Watson
980716.2bw	7/16/1998	Caswell	Trib to Hycro Creek	SR 1767	common	B.T. Watson
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1780	common	B.T. Watson
980720.2bw	7/20/1998	Caswell	Trib to Country Line Creek	SR 1537?	common	B.T. Watson
980720.3bw	7/20/1998	Caswell	Country Line Creek	NC 57	common	B.T. Watson
980720.4bw	7/20/1998	Caswell	Trib to Country Line Creek	SR 1538	common	B.T. Watson
980721.10bw	7/21/1998	Caswell	S Country Line Creek	SR 1759	common	B.T. Watson
980721.11bw	7/21/1998	Caswell	Byrds Creek	SR 1751	common	B.T. Watson
980721.2bw	7/21/1998	Caswell	Hycro Creek	SR 1710	common	B.T. Watson
980721.3bw	7/21/1998	Caswell	Panther Creek	SR 1723	common	B.T. Watson
980721.4bw	7/21/1998	Caswell	Lynch Creek	SR 1723	common	B.T. Watson
980721.6bw	7/21/1998	Caswell	Lynch Creek	SR 1771	common	B.T. Watson
980721.7bw	7/21/1998	Caswell	Negro Creek	SR 1765	common	B.T. Watson
980721.9bw	7/21/1998	Caswell	N Hycro Creek	SR 1767	common	B.T. Watson
980722.2bw	7/22/1998	Caswell	Country Line Creek	SR 1129	common	B.T. Watson
980722.4bw	7/22/1998	Caswell	Burkes Creek	SR 1732	common	B.T. Watson
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	common	B.T. Watson
980722.7bw	7/22/1998	Caswell	Hycro Creek	US 158	common	B.T. Watson
980722.8bw	7/22/1998	Caswell	Kilgore Creek	US 158	common	B.T. Watson



Table 7 (cont.). Freshwater fish species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<b><u>Gambusia holbrooki</u></b>						
980618.1bw	6/18/1998	Caswell	Hyc Creek	SR 1710	common	B.T. Watson
980701.1bw	7/1/1998	Caswell	Negro Creek	SR 1767	common	B.T. Watson
980702.2bw	7/2/1998	Caswell	Trib to Panther Creek	SR 1722	common	B.T. Watson
980702.3bw	7/2/1998	Caswell	N Hyc Creek	NC 86, SR1786	common	B.T. Watson
980721.2bw	7/21/1998	Caswell	Hyc Creek	SR 1710	common	B.T. Watson
980721.7bw	7/21/1998	Caswell	Negro Creek	SR 1765	common	B.T. Watson
980721.9bw	7/21/1998	Caswell	N Hyc Creek	SR 1767	common	B.T. Watson
980722.2bw	7/22/1998	Caswell	Country Line Creek	SR 1129	uncommon	B.T. Watson
980722.6bw	7/22/1998	Caswell	Reedy Fork	US 158	common	B.T. Watson
<b><u>Hybognathus regius</u></b>						
980721.3bw	7/21/1998	Caswell	Panther Creek	SR 1723	rare	W.C. Starnes
980722.7bw	7/22/1998	Caswell	Hyc Creek	US 158	uncommon	T.L. Fullbright, B.T. Watson
<b><u>Hypentelium nigricans</u></b>						
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1780	uncommon	B.T. Watson
980721.7bw	7/21/1998	Caswell	Negro Creek	SR 1765	uncommon	B.T. Watson
<b><u>Hypentelium roanokense</u></b>						
980721.10bw	7/21/1998	Caswell	S Country Line Creek	SR 1759	uncommon	B.T. Watson
980721.11bw	7/21/1998	Caswell	Byrds Creek	SR 1751	patchy uncommon	B.T. Watson
<b><u>Ictalurus punctatus</u></b>						
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1780	uncommon	B.T. Watson
980720.3bw	7/20/1998	Caswell	Country Line Creek	NC 57	uncommon	B.T. Watson
<b><u>Lepomis auritus</u></b>						
980618.1bw	6/18/1998	Caswell	Hyc Creek	SR 1710	common	B.T. Watson
980624.2bw	6/24/1998	Caswell	Byrds Creek	SR 1751	n/a	B.T. Watson
980624.3bw	6/24/1998	Caswell	Burkes Creek	SR 1732	n/a	B.T. Watson
980624.4bw	6/24/1998	Caswell	Penson Creek	SR 1783	common	B.T. Watson
980629.1bw	6/29/1998	Caswell	Panther Creek	SR 1723	common	B.T. Watson
980702.1bw	7/2/1998	Caswell	Trib to Panther Creek	SR 1774/1775	common	B.T. Watson

Table 7 (cont.). Freshwater fish species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<i>Lepomis auritus</i>						
980702.3bw	7/2/1998	Caswell	N Hyco Creek	NC 86, SR1786	common	B.T. Watson
980707.1bw	7/7/1998	Caswell	Hyco Creek	US 158	common	B.T. Watson
980707.2bw	7/7/1998	Caswell	Kilgore Creek	US 158		B.T. Watson
980707.3bw	7/7/1998	Caswell	Reedy Fork	US 158	common	B.T. Watson
980708.1bw	7/8/1998	Caswell	Penson Creek	SR 1736	common	B.T. Watson
980708.2bw	7/8/1998	Caswell	S Country Line Creek	SR 1736	common	B.T. Watson
980708.3bw	7/8/1998	Caswell	South Country Line Creek	SR 1759	common	B.T. Watson
980709.2bw	7/9/1998	Caswell	Trib to S Country Line Creek	SR 1730	uncommon	B.T. Watson
980709.3bw	7/9/1998	Caswell	Benay Creek	NC 62	common	B.T. Watson
980714.1bw	7/14/1998	Caswell	Country Line Creek	SR 1554	present	B.T. Watson
980714.3bw	7/14/1998	Caswell	Trib to Country Line Creek	SR 1538	common	B.T. Watson
980715.2bw	7/15/1998	Caswell	Trib to Country Line Creek	SR 1540	common	B.T. Watson
980715.4bw	7/15/1998	Caswell	Country Line Creek	SR 1565	common	B.T. Watson
980716.1bw	7/16/1998	Caswell	Country Line Creek	SR 1597	common	B.T. Watson
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1780	common	B.T. Watson
980720.3bw	7/20/1998	Caswell	Country Line Creek	NC 57	common	B.T. Watson
980720.5bw	7/20/1998	Caswell	Country Line Creek	SR 1554	common	B.T. Watson
980721.10bw	7/21/1998	Caswell	S Country Line Creek	SR 1759	common	B.T. Watson
980721.11bw	7/21/1998	Caswell	Byrds Creek	SR 1751	common	B.T. Watson
980721.1bw	7/21/1998	Caswell	Kilgore Creek	SR 1557	common	B.T. Watson
980721.2bw	7/21/1998	Caswell	Hyco Creek	SR 1710	common	B.T. Watson
980721.4bw	7/21/1998	Caswell	Lynch Creek	SR 1723	common	B.T. Watson
980721.7bw	7/21/1998	Caswell	Negro Creek	SR 1765	common	B.T. Watson
980721.9bw	7/21/1998	Caswell	N Hyco Creek	SR 1767	common	B.T. Watson
980722.1bw	7/22/1998	Caswell	Hostettler Branch	NC 150	common	B.T. Watson
980722.2bw	7/22/1998	Caswell	Country Line Creek	SR 1129	common	B.T. Watson
980722.3bw	7/22/1998	Caswell	Penson Creek	SR 1783	common	B.T. Watson
980722.4bw	7/22/1998	Caswell	Burkes Creek	SR 1732	common	B.T. Watson
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	uncommon	B.T. Watson
980722.6bw	7/22/1998	Caswell	Reedy Fork	US 158	common	B.T. Watson
980722.7bw	7/22/1998	Caswell	Hyco Creek	US 158	common	B.T. Watson
980722.8bw	7/22/1998	Caswell	Kilgore Creek	US 158	common	B.T. Watson



Table 7 (cont.). Freshwater fish species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<i><u>Lepomis cyanellus</u></i>						
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1780	uncommon	B.T. Watson
980720.3bw	7/20/1998	Caswell	Country Line Creek	NC 57	uncommon	B.T. Watson
980720.4bw	7/20/1998	Caswell	Trib to Country Line Creek	SR 1538	uncommon	B.T. Watson
980720.5bw	7/20/1998	Caswell	Country Line Creek	SR 1554	uncommon	B.T. Watson
980721.10bw	7/21/1998	Caswell	S Country Line Creek	SR 1759	uncommon	B.T. Watson
980721.11bw	7/21/1998	Caswell	Byrds Creek	SR 1751	uncommon	B.T. Watson
980721.1bw	7/21/1998	Caswell	Kilgore Creek	SR 1557	uncommon	B.T. Watson
980722.2bw	7/22/1998	Caswell	Country Line Creek	SR 1129	uncommon	B.T. Watson
980722.3bw	7/22/1998	Caswell	Penson Creek	SR 1783	uncommon	B.T. Watson
980722.4bw	7/22/1998	Caswell	Burkes Creek	SR 1732	uncommon	B.T. Watson
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	uncommon	B.T. Watson
980722.6bw	7/22/1998	Caswell	Reedy Fork	US 158	uncommon	B.T. Watson
980722.7bw	7/22/1998	Caswell	Hycro Creek	US 158	uncommon	B.T. Watson
980722.8bw	7/22/1998	Caswell	Kilgore Creek	US 158	uncommon	B.T. Watson
<i><u>Lepomis gibbosus</u></i>						
980629.1bw	6/29/1998	Caswell	Panther Creek	SR 1723	uncommon	B.T. Watson
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1780	uncommon	B.T. Watson
980720.3bw	7/20/1998	Caswell	Country Line Creek	NC 57	uncommon	B.T. Watson
980720.5bw	7/20/1998	Caswell	Country Line Creek	SR 1554	uncommon	B.T. Watson
980721.4bw	7/21/1998	Caswell	Lynch Creek	SR 1723	uncommon	B.T. Watson
980722.2bw	7/22/1998	Caswell	Country Line Creek	SR 1129	uncommon	B.T. Watson
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	uncommon	B.T. Watson
980722.6bw	7/22/1998	Caswell	Reedy Fork	US 158	uncommon	B.T. Watson
980722.7bw	7/22/1998	Caswell	Hycro Creek	US 158	uncommon	B.T. Watson
980722.8bw	7/22/1998	Caswell	Kilgore Creek	US 158	uncommon	B.T. Watson
<i><u>Lepomis macrochirus</u></i>						
980618.1bw	6/18/1998	Caswell	Hycro Creek	SR 1710	common	B.T. Watson
980624.2bw	6/24/1998	Caswell	Byrds Creek	SR 1751	present	B.T. Watson
980624.3bw	6/24/1998	Caswell	Burkes Creek	SR 1732	present	B.T. Watson
980629.1bw	6/29/1998	Caswell	Panther Creek	SR 1723	common	B.T. Watson
980701.3bw	7/1/1998	Caswell	Trib to Lynch Creek	SR 1771	common	B.T. Watson

Table 7 (cont.). Freshwater fish species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<i><b><u>Lepomis macrochirus</u></b></i>						
980702.1bw	7/2/1998	Caswell	Trib to Panther Creek	SR 1774/1775	common	B.T. Watson
980707.1bw	7/7/1998	Caswell	Hycoc Creek	US 158	common	B.T. Watson
980707.2bw	7/7/1998	Caswell	Kilgore Creek	US 158	common	B.T. Watson
980707.3bw	7/7/1998	Caswell	Reedy Fork	US 158	common	B.T. Watson
980708.1bw	7/8/1998	Caswell	Penson Creek	SR 1736	uncommon	B.T. Watson
980708.3bw	7/8/1998	Caswell	South Country Line Creek	SR 1759	common	B.T. Watson
980709.2bw	7/9/1998	Caswell	Trib to S Country Line Creek	SR 1730	uncommon	B.T. Watson
980709.3bw	7/9/1998	Caswell	Benay Creek	NC 62	common	B.T. Watson
980714.1bw	7/14/1998	Caswell	Country Line Creek	SR 1554	present	B.T. Watson
980716.1bw	7/16/1998	Caswell	Country Line Creek	SR 1597	common	B.T. Watson
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1780	common	B.T. Watson
980720.3bw	7/20/1998	Caswell	Country Line Creek	NC 57	common	B.T. Watson
980720.5bw	7/20/1998	Caswell	Country Line Creek	SR 1554	common	B.T. Watson
980721.10bw	7/21/1998	Caswell	S Country Line Creek	SR 1759	common	B.T. Watson
980721.11bw	7/21/1998	Caswell	Byrds Creek	SR 1751	common	B.T. Watson
980721.1bw	7/21/1998	Caswell	Kilgore Creek	SR 1557	common	B.T. Watson
980721.2bw	7/21/1998	Caswell	Hycoc Creek	SR 1710	common	B.T. Watson
980721.3bw	7/21/1998	Caswell	Panther Creek	SR 1723	common	B.T. Watson
980721.4bw	7/21/1998	Caswell	Lynch Creek	SR 1723	common	B.T. Watson
980721.6bw	7/21/1998	Caswell	Lynch Creek	SR 1771	common	B.T. Watson
980721.7bw	7/21/1998	Caswell	Negro Creek	SR 1765	common	B.T. Watson
980722.1bw	7/22/1998	Caswell	Hostettler Branch	NC 150	common	B.T. Watson
980722.2bw	7/22/1998	Caswell	Country Line Creek	SR 1129	common	B.T. Watson
980722.3bw	7/22/1998	Caswell	Penson Creek	SR 1783	common	B.T. Watson
980722.4bw	7/22/1998	Caswell	Burkes Creek	SR 1732	common	B.T. Watson
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	common	B.T. Watson
980722.6bw	7/22/1998	Caswell	Reedy Fork	US 158	common	B.T. Watson
980722.7bw	7/22/1998	Caswell	Hycoc Creek	US 158	common	B.T. Watson
980722.8bw	7/22/1998	Caswell	Kilgore Creek	US 158	common	B.T. Watson
<i><b><u>Lepomis sp.</u></b></i>						
980714.2bw	7/14/1998	Caswell	Kilgore Creek	SR 1557	saw nests	B.T. Watson



Table 7 (cont.). Freshwater fish species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<i><u>Luxilus albeolus</u></i>						
980721.3bw	7/21/1998	Caswell	Panther Creek	SR 1723	uncommon	B.T. Watson
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	uncommon	B.T. Watson, T.L. Fullbright
<i><u>Luxilus cerasinus</u></i>						
980618.1bw	6/18/1998	Caswell	Hycro Creek	SR 1710	common	B.T. Watson
980625.1bw	6/25/1998	Caswell	Country Line Creek	SR 1146	common	B.T. Watson
980625.2bw	6/25/1998	Caswell	Country Line Creek	SR 1129	common	B.T. Watson
980625.3bw	6/25/1998	Caswell	Country Line Creek	NC 62	common	B.T. Watson
980629.1bw	6/29/1998	Caswell	Panther Creek	SR 1723	uncommon	B.T. Watson
980701.1bw	7/1/1998	Caswell	Negro Creek	SR 1767	common	B.T. Watson
980701.3bw	7/1/1998	Caswell	Trib to Lynch Creek	SR 1771	common	B.T. Watson
980707.2bw	7/7/1998	Caswell	Kilgore Creek	US 158	common	B.T. Watson
980707.3bw	7/7/1998	Caswell	Reedy Fork	US 158	uncommon	B.T. Watson
980708.1bw	7/8/1998	Caswell	Penson Creek	SR 1736	uncommon	B.T. Watson
980708.2bw	7/8/1998	Caswell	S Country Line Creek	SR 1736	uncommon	B.T. Watson
980708.3bw	7/8/1998	Caswell	South Country Line Creek	SR 1759	uncommon	B.T. Watson
980709.1bw	7/9/1998	Caswell	Hostettler Branch	NC 150	uncommon	B.T. Watson
980709.2bw	7/9/1998	Caswell	Trib to S Country Line Creek	SR 1730	common	B.T. Watson
980720.2bw	7/20/1998	Caswell	Trib to Country Line Creek	SR 1537?	common	B.T. Watson
980720.4bw	7/20/1998	Caswell	Trib to Country Line Creek	SR 1538	uncommon	B.T. Watson
980721.10bw	7/21/1998	Caswell	S Country Line Creek	SR 1759	uncommon	B.T. Watson
980721.11bw	7/21/1998	Caswell	Byrds Creek	SR 1751	common	B.T. Watson
980721.1bw	7/21/1998	Caswell	Kilgore Creek	SR 1557	uncommon	B.T. Watson
980721.2bw	7/21/1998	Caswell	Hycro Creek	SR 1710	common	B.T. Watson
980721.3bw	7/21/1998	Caswell	Panther Creek	SR 1723	common	B.T. Watson
980721.4bw	7/21/1998	Caswell	Lynch Creek	SR 1723	common	B.T. Watson
980721.6bw	7/21/1998	Caswell	Lynch Creek	SR 1771	uncommon	B.T. Watson
980721.7bw	7/21/1998	Caswell	Negro Creek	SR 1765	common	B.T. Watson
980722.1bw	7/22/1998	Caswell	Hostettler Branch	NC 150	uncommon	B.T. Watson
980722.2bw	7/22/1998	Caswell	Country Line Creek	SR 1129	common	B.T. Watson
980722.3bw	7/22/1998	Caswell	Penson Creek	SR 1783	common	B.T. Watson
980722.4bw	7/22/1998	Caswell	Burkes Creek	SR 1732	uncommon	B.T. Watson
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	common	B.T. Watson

Table 7 (cont.). Freshwater fish species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<i><u>Luxilus cerasinus</u></i>						
980722.6bw	7/22/1998	Caswell	Reedy Fork	US 158	uncommon	B.T. Watson
980722.7bw	7/22/1998	Caswell	Hycoc Creek	US 158	abundant	B.T. Watson
980722.8bw	7/22/1998	Caswell	Kilgore Creek	US 158	common	B.T. Watson
<i><u>Lythrurus ardens</u></i>						
980618.1bw	6/18/1998	Caswell	Hycoc Creek	SR 1710	uncommon	B.T. Watson, G.B. Mottesi
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1780	uncommon	B.T. Watson, T.L. Fullbright
980721.1bw	7/21/1998	Caswell	Byrds Creek	SR 1751	uncommon	B.T. Watson, M.E. Raney
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	rare	B.T. Watson
980722.7bw	7/22/1998	Caswell	Hycoc Creek	US 158	uncommon	B.T. Watson, T.L. Fullbright
<i><u>Micropterus salmoides</u></i>						
980701.1bw	7/1/1998	Caswell	Negro Creek	SR 1767	rare	B.T. Watson
980702.1bw	7/2/1998	Caswell	Trib to Panther Creek	SR 1774/1775	rare	B.T. Watson
980707.2bw	7/7/1998	Caswell	Kilgore Creek	US 158	uncommon	B.T. Watson
980707.3bw	7/7/1998	Caswell	Reedy Fork	US 158	rare	B.T. Watson
980709.2bw	7/9/1998	Caswell	Trib to S Country Line Creek	SR 1730	rare	B.T. Watson
980709.3bw	7/9/1998	Caswell	Benay Creek	NC 62	rare	B.T. Watson
980720.3bw	7/20/1998	Caswell	Country Line Creek	NC 57	uncommon	B.T. Watson
980721.10bw	7/21/1998	Caswell	S Country Line Creek	SR 1759	uncommon	B.T. Watson
980721.1bw	7/21/1998	Caswell	Kilgore Creek	SR 1557	rare	B.T. Watson
980721.2bw	7/21/1998	Caswell	Hycoc Creek	SR 1710	uncommon	B.T. Watson
980721.4bw	7/21/1998	Caswell	Lynch Creek	SR 1723	rare	B.T. Watson
980721.5bw	7/21/1998	Caswell	Trib to Panther Creek	SR 1774	rare	B.T. Watson
980721.7bw	7/21/1998	Caswell	Negro Creek	SR 1765	rare	B.T. Watson
980721.9bw	7/21/1998	Caswell	N Hycoc Creek	SR 1767	uncommon	B.T. Watson
980722.1bw	7/22/1998	Caswell	Hostettler Branch	NC 150	rare	B.T. Watson
980722.4bw	7/22/1998	Caswell	Burkes Creek	SR 1732	rare	B.T. Watson
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	uncommon	B.T. Watson
980722.6bw	7/22/1998	Caswell	Reedy Fork	US 158	rare	B.T. Watson
980722.8bw	7/22/1998	Caswell	Kilgore Creek	US 158	uncommon	B.T. Watson



Table 7 (cont.). Freshwater fish species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<u><i>Moxostoma collapsum</i></u>						
980714.1bw	7/14/1998	Caswell	Country Line Creek	SR 1554	rare	M.E. Rancey, B.T. Watson
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR1780	rare	L. Fullbright
980720.3bw	7/20/1998	Caswell	Country Line Creek	NC 57	rare	T.L. Fullbright, B.T. Watson
980721.1bw	7/21/1998	Caswell	Kilgore Creek	SR 1557	rare	B.T. Watson
980721.7bw	7/21/1998	Caswell	Negro Creek	SR 1765	rare	M.E. Rancey, B.T. Watson
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	uncommon	T.L. Fullbright, B.T. Watson
<u><i>Moxostoma erythrurum</i></u>						
980720.5bw	7/20/1998	Caswell	Country Line Creek	SR 1554	uncommon	B.T. Watson
980721.10bw	7/21/1998	Caswell	S Country Line Creek	SR 1759	rare	B.T. Watson
980721.11bw	7/21/1998	Caswell	Byrds Creek	SR 1751	uncommon	M.E. Rancey
980722.3bw	7/22/1998	Caswell	Penson Creek	SR 1783	rare	B.T. Watson
980722.8bw	7/22/1998	Caswell	Kilgore Creek	US 158	rare	B.T. Watson
<u><i>Moxostoma sp.</i></u>						
980722.2bw	7/22/1998	Caswell	Country Line Creek	SR 1129	uncommon	B.T. Watson
<u><i>Nocomis leptocephalus</i></u>						
980618.1bw	6/18/1998	Caswell	Hyc Creek	SR 1710	common	B.T. Watson
980625.2bw	6/25/1998	Caswell	Country Line Creek	SR 1129	abundant	B.T. Watson
980625.3bw	6/25/1998	Caswell	Country Line Creek	NC 62	common	B.T. Watson
980629.1bw	6/29/1998	Caswell	Panther Creek	SR 1723	abundant	B.T. Watson
980629.3bw	6/29/1998	Caswell	Trib to Hyc Creek (Negro Ck?)	SR 1765	common	B.T. Watson
980701.1bw	7/1/1998	Caswell	Negro Creek	SR 1767	abundant	B.T. Watson
980701.3bw	7/1/1998	Caswell	Trib to Lynch Creek	SR 1771	abundant	B.T. Watson
980702.1bw	7/2/1998	Caswell	Trib to Panther Creek	SR 1774/1775	common	B.T. Watson
980702.2bw	7/2/1998	Caswell	Trib to Panther Creek	SR 1722	common	B.T. Watson
980702.3bw	7/2/1998	Caswell	N Hyc Creek	NC 86, SR1786	uncommon	B.T. Watson
980707.1bw	7/7/1998	Caswell	Hyc Creek	US 158	uncommon	B.T. Watson
980707.2bw	7/7/1998	Caswell	Kilgore Creek	US 158	common	B.T. Watson
980707.3bw	7/7/1998	Caswell	Reedy Fork	US 158	abundant	B.T. Watson
980708.1bw	7/8/1998	Caswell	Penson Creek	SR 1736	common	B.T. Watson
980708.2bw	7/8/1998	Caswell	S Country Line Creek	SR 1736	abundant	B.T. Watson
980708.3bw	7/8/1998	Caswell	South Country Line Creek	SR 1759	abundant	B.T. Watson
980709.1bw	7/9/1998	Caswell	Hostettler Branch	NC 150	common	B.T. Watson

Table 7 (cont.). Freshwater fish species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<u><i>Nocomis leptocephalus</i></u>						
980709.2bw	7/9/1998	Caswell	Trib to S Country Line Creek	SR 1730	common	B. T. Watson
980709.3bw	7/9/1998	Caswell	Benay Creek	NC 62	abundant	B. T. Watson
980714.1bw	7/14/1998	Caswell	Country Line Creek	SR 1554	common	B. T. Watson
980714.2bw	7/14/1998	Caswell	Kilgore Creek	SR 1557	abundant	B. T. Watson
980714.3bw	7/14/1998	Caswell	Trib to Country Line Creek	SR 1538	abundant	B. T. Watson
980715.2bw	7/15/1998	Caswell	Trib to Country Line Creek	SR 1540	abundant	B. T. Watson
980715.4bw	7/15/1998	Caswell	Country Line Creek	SR 1565	abundant	B. T. Watson
980716.2bw	7/16/1998	Caswell	Trib to Hyco Creek	SR 1767	common	B. T. Watson
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1780	abundant	B. T. Watson
980720.2bw	7/20/1998	Caswell	Trib to Country Line Creek	SR 1537?	abundant	B. T. Watson
980720.3bw	7/20/1998	Caswell	Country Line Creek	NC 57	abundant	B. T. Watson
980720.4bw	7/20/1998	Caswell	Trib to Country Line Creek	SR 1538	common	B. T. Watson
980720.5bw	7/20/1998	Caswell	Country Line Creek	SR 1554	common	B. T. Watson
980721.10bw	7/21/1998	Caswell	S Country Line Creek	SR 1759	abundant	B. T. Watson
980721.11bw	7/21/1998	Caswell	Byrds Creek	SR 1751	common	B. T. Watson
980721.1bw	7/21/1998	Caswell	Kilgore Creek	SR 1557	abundant	B. T. Watson
980721.2bw	7/21/1998	Caswell	Hyco Creek	SR 1710	abundant	B. T. Watson
980721.3bw	7/21/1998	Caswell	Panther Creek	SR 1723	common	B. T. Watson
980721.4bw	7/21/1998	Caswell	Lynch Creek	SR 1723	abundant	B. T. Watson
980721.5bw	7/21/1998	Caswell	Trib to Panther Creek	SR 1774	abundant	B. T. Watson
980721.6bw	7/21/1998	Caswell	Lynch Creek	SR 1771	abundant	B. T. Watson
980721.7bw	7/21/1998	Caswell	Negro Creek	SR 1765	abundant	B. T. Watson
980721.8bw	7/21/1998	Caswell	Trib to Negro Creek	SR 1767	common	B. T. Watson
980721.9bw	7/21/1998	Caswell	N Hyco Creek	SR 1767	common	B. T. Watson
980722.1bw	7/22/1998	Caswell	Hostettler Branch	NC 150	common	B. T. Watson
980722.2bw	7/22/1998	Caswell	Country Line Creek	SR 1129	common	B. T. Watson
980722.3bw	7/22/1998	Caswell	Penson Creek	SR 1783	abundant	B. T. Watson
980722.4bw	7/22/1998	Caswell	Burkes Creek	SR 1732	abundant	B. T. Watson
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	common	B. T. Watson
980722.6bw	7/22/1998	Caswell	Reedy Fork	US 158	common	B. T. Watson
980722.7bw	7/22/1998	Caswell	Hyco Creek	US 158	abundant	B. T. Watson
980722.8bw	7/22/1998	Caswell	Kilgore Creek	US 158	abundant	B. T. Watson



Table 7 (cont.). Freshwater fish species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<u><i>Notropis amoenus</i></u>						
980716.1bw	7/16/1998	Caswell	Country Line Creek	SR 1597	uncommon	T.L. Fullbright
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1780	uncommon	T.L. Fullbright
980720.3bw	7/20/1998	Caswell	Country Line Creek	NC 57	uncommon	W.C. Starnes, T.L. Fullbright
<u><i>Notropis procne</i></u>						
980618.1bw	6/18/1998	Caswell	Hycro Creek	SR 1710	abundant	B.T. Watson, G.B. Mottesi
980625.2bw	6/25/1998	Caswell	Country Line Creek	SR 1129	abundant	B.T. Watson
980625.3bw	6/25/1998	Caswell	Country Line Creek	NC 62	common	B.T. Watson
980709.2bw	7/9/1998	Caswell	Trib to S Country Line Creek	SR 1730	common	B.T. Watson, T.L. Fullbright
980716.1bw	7/16/1998	Caswell	Country Line Creek	SR 1597	common	B.T. Watson
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1780	abundant	B.T. Watson, T.L. Fullbright
980720.3bw	7/20/1998	Caswell	Country Line Creek	NC 57	abundant	B.T. Watson
980720.5bw	7/20/1998	Caswell	Country Line Creek	SR 1554	abundant	B.T. Watson
980721.10bw	7/21/1998	Caswell	S Country Line Creek	SR 1759	common	B.T. Watson
980721.11bw	7/21/1998	Caswell	Byrds Creek	SR 1751	abundant	B.T. Watson
980721.2bw	7/21/1998	Caswell	Hycro Creek	SR 1710	abundant	B.T. Watson
980721.4bw	7/21/1998	Caswell	Lynch Creek	SR 1723	abundant	B.T. Watson
980721.6bw	7/21/1998	Caswell	Lynch Creek	SR 1771	common	B.T. Watson
980721.7bw	7/21/1998	Caswell	Negro Creek	SR 1765	abundant	B.T. Watson
980721.9bw	7/21/1998	Caswell	N Hycro Creek	SR 1767	common	B.T. Watson
980722.3bw	7/22/1998	Caswell	Penson Creek	SR 1783	abundant	B.T. Watson
980722.4bw	7/22/1998	Caswell	Burkes Creek	SR 1732	common	B.T. Watson
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	common	B.T. Watson
<u><i>Notropis scepticus</i></u>						
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1780	uncommon	T.L. Fullbright
<u><i>Noturus insignis</i></u>						
980618.1bw	6/18/1998	Caswell	Hycro Creek	SR 1710	rare	B.T. Watson
980625.1bw	6/25/1998	Caswell	Country Line Creek	SR 1146	rare	B.T. Watson
980625.3bw	6/25/1998	Caswell	Country Line Creek	NC 62	rare	B.T. Watson
980629.1bw	6/29/1998	Caswell	Panther Creek	SR 1723	rare	B.T. Watson
980708.1bw	7/8/1998	Caswell	Penson Creek	SR 1736	rare	B.T. Watson
980708.2bw	7/8/1998	Caswell	S Country Line Creek	SR 1736	rare	B.T. Watson
980709.1bw	7/9/1998	Caswell	Hostettler Branch	NC 150	rare	B.T. Watson

Table 7 (cont.). Freshwater fish species found in Caswell Game Land and associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<b><u>Noturus insignis</u></b>						
980715.1bw	7/15/1998	Caswell	Country Line Creek	1780	rare	B.T. Watson
980715.3bw	7/15/1998	Caswell	Country Line Creek	NC 57	rare	B.T. Watson
980716.1bw	7/16/1998	Caswell	Country Line Creek	SR 1597	uncommon	B.T. Watson
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1780	uncommon	B.T. Watson
980720.3bw	7/20/1998	Caswell	Country Line Creek	NC 57	uncommon	B.T. Watson
980720.5bw	7/20/1998	Caswell	Country Line Creek	SR 1554	uncommon	B.T. Watson
980721.10bw	7/21/1998	Caswell	S Country Line Creek	SR 1759	rare	B.T. Watson
980721.11bw	7/21/1998	Caswell	Byrds Creek	SR 1751	rare	B.T. Watson
980721.3bw	7/21/1998	Caswell	Panther Creek	SR 1723	rare	B.T. Watson
980722.1bw	7/22/1998	Caswell	Hostettler Branch	NC 150	uncommon	B.T. Watson
980722.2bw	7/22/1998	Caswell	Country Line Creek	SR 1129	rare	B.T. Watson
980722.3bw	7/22/1998	Caswell	Penson Creek	SR 1783	rare	B.T. Watson
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	rare	B.T. Watson
980722.7bw	7/22/1998	Caswell	Kilgore Creek	US 158	rare	B.T. Watson
980722.8bw	7/22/1998	Caswell	Hycro Creek	US 158	uncommon	B.T. Watson
<b><u>Perca flavescens</u></b>						
980707.2bw	7/7/1998	Caswell	Kilgore Creek	US 158	common	B.T. Watson
980722.8bw	7/22/1998	Caswell	Hycro Creek	US 158	abundant	B.T. Watson
<b><u>Percina peltata</u></b>						
980720.3bw	7/20/1998	Caswell	Country Line Creek	NC 57	rare	T.L. Fullbright
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	rare	B.T. Watson, G.B. Mottesi
<b><u>Percina roanoka</u></b>						
980625.3bw	6/25/1998	Caswell	Country Line Creek	NC 62	rare	B.T. Watson
980708.3bw	7/8/1998	Caswell	South Country Line Creek	SR 1759	rare	B.T. Watson
980714.1bw	7/14/1998	Caswell	Country Line Creek	SR 1554	rare	B.T. Watson, M.E. Raney
980714.2bw	7/14/1998	Caswell	Kilgore Creek	SR 1557	rare	B.T. Watson
980715.3bw	7/15/1998	Caswell	Country Line Creek	NC 57	rare	G.B. Mottesi
980720.3bw	7/20/1998	Caswell	Country Line Creek	NC 57	rare	B.T. Watson, T.L. Fullbright
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	rare	T.L. Fullbright, B.T. Watson



Table 7 (cont.). Freshwater fish species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<b><i>Phoxinus oreas</i></b>						
980618.1bw	6/18/1998	Caswell	Hyc Creek	SR 1710	common	B.T. Watson
980624.2bw	6/24/1998	Caswell	Byrds Creek	SR 1751	present	B.T. Watson
980625.2bw	6/25/1998	Caswell	Country Line Creek	SR 1129	common	B.T. Watson
980625.3bw	6/25/1998	Caswell	Country Line Creek	NC 62	common	B.T. Watson
980629.1bw	6/29/1998	Caswell	Panther Creek	SR 1723	common	B.T. Watson
980629.3bw	6/29/1998	Caswell	Trib to Hyc Creek (Negro Ck?)	SR 1765	uncommon	B.T. Watson
980701.1bw	7/1/1998	Caswell	Negro Creek	SR 1767	common	B.T. Watson
980701.3bw	7/1/1998	Caswell	Trib to Lynch Creek	SR 1771	common	B.T. Watson
980702.1bw	7/2/1998	Caswell	Trib to Panther Creek	SR 1774/1775	common	B.T. Watson
980707.2bw	7/7/1998	Caswell	Kilgore Creek	US 158	common	B.T. Watson
980708.1bw	7/8/1998	Caswell	Penson Creek	SR 1736	common	B.T. Watson
980708.3bw	7/8/1998	Caswell	South Country Line Creek	SR 1759	common	B.T. Watson
980709.2bw	7/9/1998	Caswell	Trib to S Country Line Creek	SR 1730	common	B.T. Watson
980709.3bw	7/9/1998	Caswell	Benay Creek	NC 62	common	B.T. Watson
980714.2bw	7/14/1998	Caswell	Kilgore Creek	SR 1557	common	B.T. Watson
980715.2bw	7/15/1998	Caswell	Trib to Country Line Creek	SR 1540	common	B.T. Watson
980716.2bw	7/16/1998	Caswell	Trib to Hyc Creek	SR 1767	uncommon	B.T. Watson
980721.10bw	7/21/1998	Caswell	S Country Line Creek	SR 1759	common	B.T. Watson
980721.11bw	7/21/1998	Caswell	Byrds Creek	SR 1751	abundant	B.T. Watson
980721.1bw	7/21/1998	Caswell	Kilgore Creek	SR 1557	common	B.T. Watson
980721.5bw	7/21/1998	Caswell	Trib to Panther Creek	SR 1774	common	B.T. Watson
980721.6bw	7/21/1998	Caswell	Lynch Creek	SR 1771	common	B.T. Watson
980721.7bw	7/21/1998	Caswell	Negro Creek	SR 1765	abundant	B.T. Watson
980721.8bw	7/21/1998	Caswell	Trib to Negro Creek	SR 1767	uncommon	B.T. Watson
980721.9bw	7/21/1998	Caswell	N Hyc Creek	SR 1767	common	B.T. Watson
980722.3bw	7/22/1998	Caswell	Penson Creek	SR 1783	common	B.T. Watson
980722.4bw	7/22/1998	Caswell	Burkes Creek	SR 1732	common	B.T. Watson
980722.8bw	7/22/1998	Caswell	Hyc Creek	US 158	common	B.T. Watson
<b><i>Pomoxis nigromaculatus</i></b>						
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1780	rare	B.T. Watson
<b><i>Pylodictus olivaris</i></b>						
980720.3bw	7/20/1998	Caswell	Country Line Creek	NC 57	present	B.T. Watson

Table 7 (cont.). Freshwater fish species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<i><u>Semotilus atromaculatus</u></i>						
980625.3bw	6/25/1998	Caswell	Country Line Creek	NC 62	common	B.T. Watson
980629.1bw	6/29/1998	Caswell	Panther Creek	SR 1723	uncommon	B.T. Watson
980629.3bw	6/29/1998	Caswell	Trib to Hyco Creek (Negro Ck?)	SR 1765	uncommon	B.T. Watson
980701.1bw	7/1/1998	Caswell	Negro Creek	SR 1767	common	B.T. Watson
980702.1bw	7/2/1998	Caswell	Trib to Panther Creek	SR 1774/1775	uncommon	B.T. Watson
980702.2bw	7/2/1998	Caswell	Trib to Panther Creek	SR 1722	uncommon	B.T. Watson
980702.3bw	7/2/1998	Caswell	N Hyco Creek	NC 86, SR1786	uncommon	B.T. Watson
980707.1bw	7/7/1998	Caswell	Hyco Creek	US 158	uncommon	B.T. Watson
980707.2bw	7/7/1998	Caswell	Kilgore Creek	US 158	uncommon	B.T. Watson
980707.3bw	7/7/1998	Caswell	Reedy Fork	US 158	common	B.T. Watson
980708.1bw	7/8/1998	Caswell	Penson Creek	SR 1736	uncommon	B.T. Watson
980708.2bw	7/8/1998	Caswell	S Country Line Creek	SR 1736	common	B.T. Watson
980709.1bw	7/9/1998	Caswell	Hostettler Branch	NC 150	uncommon	B.T. Watson
980709.2bw	7/9/1998	Caswell	Trib to S Country Line Creek	SR 1730	uncommon	B.T. Watson
980709.3bw	7/9/1998	Caswell	Benay Creek	NC 62	uncommon	B.T. Watson
980714.1bw	7/14/1998	Caswell	Country Line Creek	SR 1554	common	B.T. Watson
980714.2bw	7/14/1998	Caswell	Kilgore Creek	SR 1557	uncommon	B.T. Watson
980714.3bw	7/14/1998	Caswell	Trib to Country Line Creek	SR 1538	common	B.T. Watson
980716.2bw	7/16/1998	Caswell	Trib to Hyco Creek	SR 1767	uncommon	B.T. Watson
980720.1bw	7/20/1998	Caswell	Country Line Creek	SR 1780	common	B.T. Watson
980720.3bw	7/20/1998	Caswell	Country Line Creek	NC 57	common	B.T. Watson
980721.1bw	7/21/1998	Caswell	Kilgore Creek	SR 1557	common	B.T. Watson
980721.2bw	7/21/1998	Caswell	Hyco Creek	SR 1710	common	B.T. Watson
980721.3bw	7/21/1998	Caswell	Panther Creek	SR 1723	common	B.T. Watson
980721.4bw	7/21/1998	Caswell	Lynch Creek	SR 1723	uncommon	B.T. Watson
980721.5bw	7/21/1998	Caswell	Trib to Panther Creek	SR 1774	common	B.T. Watson
980721.6bw	7/21/1998	Caswell	Lynch Creek	SR 1771	uncommon	B.T. Watson
980721.7bw	7/21/1998	Caswell	Negro Creek	SR 1765	common	B.T. Watson
980721.8bw	7/21/1998	Caswell	Trib to Negro Creek	SR 1767	uncommon	B.T. Watson
980721.9bw	7/21/1998	Caswell	N Hyco Creek	SR 1767	common	B.T. Watson
980722.1bw	7/22/1998	Caswell	Hostettler Branch	NC 150	uncommon	B.T. Watson
980722.2bw	7/22/1998	Caswell	Country Line Creek	SR 1129	uncommon	B.T. Watson



Table 7 (cont.). Freshwater fish species found in Caswell Game Land associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<i>Semotilus atromaculatus</i>						
980722.3bw	7/22/1998	Caswell	Penson Creek	SR 1783	common	B.T. Watson
980722.4bw	7/22/1998	Caswell	Burkes Creek	SR 1732	common	B.T. Watson
980722.5bw	7/22/1998	Caswell	Country Line Creek	NC 62	uncommon	B.T. Watson
980722.8bw	7/22/1998	Caswell	Hycro Creek	US 158	common	B.T. Watson

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